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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

Institute of British Foundrymen.

MAY 7.

Lancashire Branch:—Final lecture of the session at Manchester. "Some Aspects of Oil-Engine Foundry Practice," by H. E. Beardshaw.

Mould-Drying Problems.

We have already candidly admitted that when preparing a description of the Fullwood Foundry we used a loose phrase in connection with the efficiency of the drying ovens installed there. In a foundry of any considerable dimensions it is neither easy nor desirable to investigate and report in detail upon each item of plant installed. Rather does one concentrate on emphasising the latest developments in each plant described.

Mr. Calder has returned to the subject by insisting that he had taken into consideration the "time" factor. The problem involved in drying moulds and cores cannot be represented as a mathematical constant, because some foundries, especially where loam is used, do more than effect the removal of water; they definitely take the moulds or cores to a predetermined temperature, much higher than necessary to evolve uncombined water. Other foundries are content to remove water from the shell of moulds or cores. The complexity of the problem can be gauged from a consideration of the following points:—(1) The fact that the process involves relative low temperatures is against thermal efficiency; (2) rate of input of heat has usually to be slow, as excessive speed may cause surface disintegration; (3) slow rate of heat input mitigates against efficiency; (4) the atmosphere of the furnace has to be changed frequently in order to replace with dry air the steam-saturated atmosphere; (5) dry air, especially when stationary, is a poor conductor of heat; (6) usually, no guarantee can be given that the stove will be filled in the same manner or to the same extent two days running; (7) synchronisation with the general work of the foundry may call for a certain amount of sacrifice of efficiency; (8) thermal efficiency may not be synonymous with economic efficiency, viewed from either the particular aspect of the furnace itself or from the general running of the foundry. For instance, electric heating might yield a 75 per cent. thermal efficiency, but the local cost of power may be prohibitive, or waste gases may be available from some other plant. The thermal—not necessarily the ultimate—efficiency should be the heat units available from the fuel burnt related to those necessary for heating up the moulds and cores to a definite predetermined point beyond 100 deg. C., whilst ensuring that the water contained in the moulds is removed from the oven. The greatest factor in this calculation will obviously be the ratio of weight of material to be dried to cubic capacity of the stove (or superficial area of the walls and roof). Summarised, the efficiency of a stove can be ascribed to care in controlling the following factors:—(1) Well-insulated walls; (2) speed of operation; (3) rapid combustion of fuel to overcome continuous heat dissipation; (4) a well-filled stove; (5) flue arrangements for atmosphere control. The results obtained by one foundry cannot be compared with another unless the specific heat of the moulds and cores is taken into consideration. We should imagine that a well-rammed mould will have a considerably lower specific heat than those which have been lightly compressed.

Ingot Moulds.

In spite of the large annual tonnage of cast iron used in ingot moulds and of the fact that the cost of ingot moulds represents quite an appreciable fraction of the cost of steel ingot, the amount of published matter relating to ingot moulds is extremely small, whether it be English, French or German. The Papers presented to the Iron and Steel Institute this week on this subject are therefore particularly welcome. They form part of the fourth report on the heterogeneity of steel ingots presented by the Heterogeneity Committee. The first Paper (by Mr. J. G. Pearce and Mr. E. Morgan) deals with the thermal properties of ingot-mould irons, and the second (by Dr. Donaldson) with the thermal conductivities of ingot-mould irons. The former makes it clear that while longer-life ingot moulds may be an ultimate consequence of this work, the immediate object is to furnish thermal data for the Heterogeneity Committee; their object, in turn, is to produce the perfect steel ingot, and in order to do this they require to know how the heat is lost by the mould through radiation and conduction. Measurements have therefore been made on typical ingot-mould irons of the usual type—three in number. Details are given in the two Papers of analyses and microstructure, thermal conductivity, thermal expansion and dilatation, specific heat and density. Figures are also given of some electrical resistance measurements at ordinary temperatures with a view to ascertaining how far these may be used as an index to the more difficult thermal conductivity measurements.

The moulds tested were drawn from three different sources, and in all cases were made at one works and used at another. Results are given both before and after use, and some information is given respecting length of life. In one case samples were taken from the top and from the bottom of the mould.

Although the samples conform to the generally accepted composition for ingot moulds such as steelmakers are prepared to use up as steel-furnace scrap, the properties differ to a surprising degree, and the general conclusion arrived at is that there is no direct correlation between composition and physical properties. The thermal conductivity increases during the life of the mould on account of the gradual conversion of pearlite to the better conducting ferrite.

The Heterogeneity Committee has expressed its great appreciation of the results, which should be of material assistance in prosecuting both theoretical studies and practical tests of the rate of cooling of steel ingot.

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XUM

Thermal Properties of Ingot Mould Irons.*

By J. G. Pearce, M.Sc., and E. Morgan, M.Sc.
(British Cast Iron Research Association.)

Attention having been drawn to the paucity of information on the thermal and other properties of ingot mould irons, the British Cast Iron Research Association undertook to provide information on these properties. The Heterogeneity Committee made it abundantly clear that it did not in any way question the quality of ingot moulds as now supplied and that it realised the extent to which the life of an ingot mould was governed by the treatment it received in the steelworks. The physical properties called for were required solely for the purpose of elucidating all the factors incidental to the production of the perfect ingot. This confined the present stage of the investigation to the examination of ingot mould material as now made. It is well known that ingot moulds are made of hematite iron, since the most satisfactory way of disposing of discarded moulds is to melt them in place of pig-iron in the steel furnace. This demands the use of metal low in sulphur and phosphorus—that is, a hematite iron—which in turn involves the use of pig characterised by a high total-carbon content. The silicon content is usually such as to yield a soft grey iron, for a mottled or white structure would promote premature cracking. The manganese content is that characteristic of whatever hematite iron is employed.

Experience has shown that it is virtually impossible to correlate the mould life with the chemical composition, and A. W. and H. Brearley, in quoting analyses of moulds giving good life, add that moulds of similar composition and identical in every other visible respect have been known to do very badly. For ordinary crucible-melted grey irons, work carried out by the British Cast Iron Research Association offers scientific confirmation of this experience. It has been found that the properties of grey cast iron are determined by the structure as well as by the composition, and that irons of very similar compositions may have markedly different structures and hence different properties. In fact, the wide variation in behaviour of irons of similar composition forms one of the commonest anomalies met with in practical experience. These differences arise in part from variations in the structure of the raw material (even when the composition remains the same), and in part from differences in the melting conditions.

Germs and Structure.

The most satisfactory explanation of structural differences in irons of similar composition available up to the present suggests that during ordinary cupola melting the temperature reached and the duration of melting are insufficient to ensure the complete solution of the graphite present in the original charges, with the result that graphite germs pass from the furnace into the ladle. These will vary in size from melt to melt according to the coarseness of the original graphite (that is, according to the fracture of the material) and to the temperature reached in the furnace, and hence will vary from one cast to another when a change has taken place in the raw material or when different furnaces are used. Differences in the graphite size and distribution result in differing physical and mechanical properties. The properties of the material in the casting will in general vary according as the structure is ferrite—fine-graphite (produced when the whole of the initial graphite is dissolved) or pearlite—flake-graphite (produced when nuclei remain in the melt) or a mixture of the two (produced frequently in thin sections where the time of cooling is too short to permit nuclei to grow). Ferrite—fine-graphite is not often met with in cupola-melted irons cast into thick sections, such as ingot moulds, but a considerable variation in properties is possible in the pearlite—flake-graphite range owing to the variation in size of flake associated with the pearlite. The mechanical and physical properties of ingot mould irons, which for reasons mentioned above conform more or less to a typical composition, may thus exhibit considerable variations. This is, indeed, confirmed by the present report, where physical differences shown to exist between moulds from three different makers transcend what would normally be expected from the comparatively slight differences due to composition variations. Should the conditions be such as to yield a mixture of ferrite and flake graphite with pearlite and flake graphite there will be heterogeneity with respect to the thermal properties corresponding with the structural heterogeneity within the one mould, but those hitherto examined in the present investigation are almost wholly pearlitic. Where uniformity of physical properties is of importance, uniformity of structure is obviously desirable.

Suitability of Heat-Resisting Irons.

The analysis which ingot mould makers are compelled to adopt is naturally different from the usual type of heat-resisting iron. Conventional heat-resisting irons are low in total carbon, high in combined carbon (hence having a minimum size and quantity of graphite), and low in silicon, having a structure of pearlite and flake graphite. Ingot mould irons tend to be high in total carbon, and medium to low in combined carbon, accompanied by medium silicon content. There is no doubt that the universal use of this type of iron for ingot moulds is dictated by very sound practical reasons. The British Cast Iron Research Association has been responsible for the development of a new series of heat-resisting irons low in total carbon, high in silicon and of almost negligible combined carbon content, the graphite being in a fine state of division (supercooled). Opportunity is here taken specifically to state that these irons (called Silal irons) are not recommended for ingot moulds, whether for ferrous or non-ferrous ingots. Experience of small experimental ingot moulds has shown that ordinary Silal cracks, not at high temperatures, but at a black heat. Hitherto unpublished tests at temperatures of 800 deg. C. have shown that Silal irons are actually more rigid than good engineering irons at the same temperature, and have a ductility at this temperature comparable with that of ordinary malleable cast iron at air temperature. For toughness at air temperatures where the ordinary Silal iron is apt to be brittle, alloyed Silal irons are being developed. Experience points to the fact that castings, such as ingot moulds, required to resist sudden thermal stresses without cracking, should have a high carbon content, which the ordinary Silal irons do not possess, and the question of the improvement of ingot mould iron resolves itself into determining the most suitable quantity and distribution of the graphite. A measure of openness of grain in the thick sections used for ingot moulds is inevitable with the composition and sections employed, and may, indeed, prove necessary to long life.

Apart from the influence of the composition, melting conditions and structure, the life of ingot moulds is affected by such procedures as seasoning (that is, storing the moulds before use), annealing before putting into service (a rapid seasoning process), and warming up the moulds before and cooling them after use; top- and bottom-pouring the ingots, and splashing during pouring also have their effect.

Before the experiments now reported were put in hand, the British Cast Iron Research Association called meetings of ingot mould makers in different parts of the country, who promised their co-operation in respect of supply of material as rapidly as the experimental work could be undertaken. The results of tests in three ingot mould irons are presented in this report. Three additional samples are also under test, being moulds made at one works and used at another, having given long, medium and short lives respectively. It is also hoped to be able to study the properties of mould metal at different periods in the life of the mould.

Properties Tested.

Tests on the following physical properties are required: Analysis and microstructure, thermal conductivity, thermal expansion and dilatation properties, specific heat and density. Tests on the four last-mentioned properties are, of course, required at all temperatures up to the highest reached by the mould in practice. McCance suggests that the temperature of the mould surface does not ordinarily exceed 930 deg. C., and this is confirmed by experience in the examination of discarded moulds. Direct impingement of the metal stream on the mould face may result in higher temperature locally.

Dr. J. W. Donaldson kindly undertook to co-operate with the Association in carrying out the tests on thermal conductivity. These test results actually go up to 425 deg. C., and their nature suggests that extrapolation up to somewhat higher temperatures might be made. The remaining determinations now reported were carried out in the laboratories of the British Cast Iron Research Association. Ordinary mechanical tests were considered of doubtful value when applied to ingot moulds and were not undertaken. The irons, however, were of a soft and readily machinable type, having a Brinell hardness of about 160 to 180.

Thermal expansion, dilatation and density values up to 900 deg. C. are given, along with analyses and microstructures. No specific heat determinations on these materials have been made up to the present, but it is hoped to carry out such determinations in the near future. For reasons indicated below, it was decided to carry out certain electrical resistivity measurements at temperatures up to 900 deg. C., but this work has so far been confined to room temperature. In view of the scarcity of data on the fundamental properties of cast iron, a brief summary is given of the state of present knowledge regarding such fundamental properties as thermal conductivity, electrical conductivity and specific heat.

Thermal and Electrical Conductivity.

Valuable information on the thermal conductivity of cast iron has been obtained by Donaldson, who carried out a systematic study of various types of cast irons and obtained results showing the influence of the composition, structure and temperature on this property. Dr. Donaldson has extended this work to include ingot mould irons, and these have been tested up to a temperature of 425 deg. C. This is a marked advance on previous available knowledge of this fundamental property, but problems connected with the transference of heat through the walls of ingot moulds after the steel has been teemed require for their solution a precise knowledge of the thermal properties of cast iron at much higher temperatures, since it has been estimated that the temperature on the inside of the wall of the mould may attain 930 deg. C. Donaldson finds that there is a quite definite lowering of the conductivity with the temperature up to the maximum temperature at which he tested his irons. Above

* Extracted from the Fourth Report on the Heterogeneity of Steel Ingots, sponsored by the Iron and Steel Institute and other Associations.

this temperature (425 deg. C. in the case of the ingot mould irons tested) it can only be surmised that this decrease in conductivity is continuous. The inherent difficulties of the method of determining the thermal conductivity of cast iron make it impossible, with the present apparatus, to extend the work to higher temperatures and obtain the same degree of precision. The presence of critical points at higher temperatures and the structural changes that are known to result from an increase in temperature, even below the critical point, preclude the possibility of extrapolation beyond about 550 deg. C.

The close connection between thermal conductivity and electrical conductivity suggests a way out of the difficulty, since electrical conductivity determinations offer relatively little difficulty, even at elevated temperatures. It is necessary, however, to determine the precise relationship, if any, that exists between the electrical and thermal conductivity before this becomes possible.

In the case of pure metals, a fairly simple relationship between the two properties has been arrived at on theoretical grounds. There is now ample experimental evidence in support of it. The relationship is conveniently put in the form $\frac{K}{\lambda T}$ = constant (K being the thermal conductivity, λ the electrical resistivity and T the absolute temperature). $\frac{K}{\lambda T}$ is referred to as Lorenz's coefficient. Schofield has established the fact that this coefficient, which was known to be constant for certain pure metals with the range −100 deg. to +100 deg. C., is also constant up to 700 deg. C. In the case of aluminium, there is a small increase with temperature. Griffiths has shown, in the case of certain aluminium alloys and bronzes, that the value of the function does not differ greatly from that of the metal which forms the principal part of the alloy.

In the case of grey cast irons, the relationship is not so clearly defined, but a consideration of the results of investigations on the electrical conductivity when taken in conjunction with the recent results obtained by Donaldson on thermal conductivity show that it is possible that such a simple relationship does exist. Thus, Pinsl found that an increase in the silicon content of 1 per cent. has the effect of increasing the specific electrical resistivity of grey cast irons by 12 to 14 microhms per c.c. at ordinary temperatures. Furthermore, an increase of 1 per cent. in the graphite content, other things being equal, has the effect of increasing the resistivity by 10 to 12 microhms per c.c., according to the size and distribution of the graphite. Refining the graphite and grain-size diminishes the resistivity, the minimum resistivity for any particular composition being obtained with a structure consisting of fine-graphite-ferrite eutectic in a ground-mass free from cementite. Increasing the combined carbon has the effect of increasing the resistivity very markedly. Annealing so as to decompose the combined carbon decreases the resistivity, the maximum effect being produced when the combined carbon is originally in the sorbitic form. Donaldson's results show that silicon lowers the thermal conductivity considerably; free ferrite is a much better heat conductor than eutectoid pearlite. The primary effect of heat-treatment at 550 deg. C. is to increase the conductivity, due to the decomposition of eutectoid pearlite into ferrite and graphite. These conclusions are substantially what would be expected if the Lorenz coefficient holds for grey cast irons.

In the case of white irons, Masumoto has shown that the graphitisation which takes place on annealing produces a considerable increase in both the thermal and the electrical conductivity, but the Lorenz function is also increased, indicating that the thermal conductivity is improved to a greater extent than the electrical conductivity. The formation of 1 per cent. of graphite by the decomposition of combined carbon decreases the specific electrical resistance by about 0.85 per cent. and the thermal resistance by 3.99 per cent. He also finds that the two conductivities decrease at first rapidly and then more slowly with increasing total carbon, but that the Lorenz coefficient is only slightly increased.

Specific Heat.

There is very little published work on the specific heats of cast irons whose compositions approximate to those of ingot-mould materials. On the other hand, many determinations have been made of the specific heats of pure irons and carbon steels over wider ranges of temperature, and the results are generally in good agreement. It is only to be expected that the critical and other anomalous changes brought about by temperature variations will, even in case of pure iron, affect the normal variation in the specific heat which takes place with a change in temperature. Carbon steels possess a further complication, due to the presence of carbon (in its various forms) and the other elements such as manganese, silicon, etc., which are invariably present in small quantities. Cast irons, naturally, present a still more complicated problem, but at the same time many of the factors that affect the specific heats of pure iron and steels will exert their influences in the case of cast irons, and, therefore, in view of the dearth of information on cast irons a brief consideration of steel and pure iron will be helpful.

The method generally adopted for the determination of specific heat is the "method of mixtures"—the sample whose specific heat is required is heated uniformly to a certain temperature and then quickly immersed in water or ice contained in a calorimeter. Modifications of this method have also been employed, with a view to obtaining the specific heat over a narrower range of temperatures than is possible with the original method. It is doubtful whether it is necessary to adopt such modifications in the case of cast iron, since the simple water or ice calorimeter method enables one to obtain the heat-content of a particular sample at any temperature quite readily, and when necessary a close approximation to the specific heat over a narrow temperature range can also be obtained.

A comprehensive review of the published data on the specific heats of pure iron and steels is given by Hatfield. In the case of pure iron, the mean specific heat within the range of 0 deg. to 100 deg. C. is very nearly 0.111 units, but the value increases very rapidly just below the magnetic change point. In the γ region the value varies between 0.145 and 0.166 units. In passing, it should be pointed out that the absolute value of the specific heat as determined by Dearden varies a great deal at low temperatures (170 to 393 deg. C.). It is also shown by Hatfield that carbon in annealed steels increases the specific heat; thus, over the temperature range 20 to 150 deg. C. the average specific heat is increased by 0.0058 units by the addition of 1 per cent. of carbon, whilst over the range 20 to 1,250 deg. C. the increase in the specific heat is 0.0052 units. One per cent. of manganese produces an increase in the specific heat of 0.0006 units over the range 0 to 100 deg. C. With regard to the influence of silicon, the position is not so clear, since Brown finds that silicon up to 2 per cent. increases the specific heat by 0.003 units, whereas Oberhoffer and Grosse state that transformer steel containing 4 per cent. of silicon had a lower specific heat than pure iron within the temperature range 0 to 100 deg. C.

The balance of the Paper details the composition of the ingot mould irons tested; their microstructure; their thermal expansions, dilatation properties and densities, and their electrical resistivities at room temperature.

(*Concluded on page* 284.)

Random Shots.

A correspondent has very kindly pointed out to me that the programme of the Newcastle I.B.F. Conference, as circulated to members, promises a super-attraction for June. On the ninth of the month participants are invited to a "civic reception and dance by the Lord Mayor and Lady Mayoress of Newcastle-upon-Tyne." I presume that Alderman and Mrs. J. G. Nixon are carefully going through their paces in preparation for the event, which should draw quite a record attendance, because it will be an unusual innovation for an Institute function.

* * *

The organisers of the Conference programme have arranged things very creditably, and the motor coaches for the annual excursion should, I imagine, be crowded to overflowing. The country through which the route passes is noted for lovely scenery, and (as the guide books say) is rich in historical associations. "Marksman" is intrigued with the idea of being photographed while standing before the Roman Wall in an "Alone I did it" attitude, and the amateur photographers in the party will have a busy time, he expects, with others who are also intrigued by the idea.

* * *

"Marksman" begins to wonder whether the depression has caused a halt in the flow of new stories, because an original story is now very much like corn in the land of Egypt. One or two have come his way recently which he thinks are good enough to be passed on.

* * *

A professor once remarked that he used three pairs of spectacles, and, asked why that was, he said: "I have one pair for long sight, one for short sight, and one to look for the other two."

* * *

Rastus went into a chemist's shop to buy a toothbrush. The chemist asked what sized toothbrush he wanted. "De biggest and bestest you got," said Rastus, "dah is ten in mah family."

* * *

Infidel (to lame explorer): "Ho, Christian! How's your bunion?" Explorer: "Fine, Abdul, how's your koran?"

* * *

"I never worry about my wife looking at another man when I'm on a business trip," said a very talkative man to his fellow-traveller. "She is quite crazy about me." "Doesn't she ever have sane intervals?" asked the other.

MARKSMAN.

Publication Received.

Aluminium.—It will be remembered that last year the large aluminium-producing concerns organised an international aluminium competition. The British Aluminium Company, Limited, of Adelaide House, King William Street, has in this connection published in a 40-page brochure a series of abstracts of the entries. Apart from being an essential to those thinking of entering this year, the booklet is of definite interest to the trade in general, as showing avenues for new business in aluminium castings. For instance, the first prize was gained by an essay showing how a glove factory can absorb very considerable quantities of the metal.

Metal for Steel Castings.

The London Section of the Institute of British Foundrymen in recent years has procured the services of a foreign foundryman of international reputation as an annual lecturer. This year, the members were fortunate in having Dr. Guido Vanzetti as their choice.

The Chairman (Mr. H. G. Sommerfield), in welcoming Dr. Vanzetti, said that he promised to become just as brilliant an engineer and as ardent an advocate of metallurgy as his father, Signor Carlo Vanzetti, C.B.E. Dr. Guido Vanzetti had graduated as a Doctor of Engineering in Milan and was a partner with his father in the Milan Steel Foundry, which was one of the largest in Italy. The members of the Institute of British Foundrymen would remember the courtesy, the hospitality and the cordial welcome which he and his father had extended to all visitors, particularly the Britishers, on the occasion of the last International Foundry Congress in Milan. The members of the London Branch were extremely grateful that he had travelled from Italy to England, at a time when the whole of the industries of the world were experiencing difficulty, to give us the benefit of his views, experience and research in the Italian foundry industry.

The Advantages of Tropenas Steel.

Mr. J. Deschamps, after congratulating Dr. Vanzetti on his very interesting Paper, expressed surprise that in his foundry at Milan the cost of producing steel with the surface-blown converters was much higher than the cost of steel obtained from electric furnaces, although the charge for electric current was as high as 0.75d. per unit and the cost of scrap about 52s. per ton. This was probably due to the extraordinarily heavy losses he was obtaining in his conversion, which losses, he had said, were between 20 per cent. and 30 per cent. of the metal charged into the cupola. This was twice as much as was obtained by good modern converter practice. The pressure used by Dr. Vanzetti for blowing his converter was about 40 cm. mercury, which was about 8 lbs. per sq. in.—at least three times greater than it should be. Mr. Deschamps expressed the view that when operating side-blown converters it was best to ignore all indications given by text-books on the subject, and that whereas the various authors who had dealt with this matter recommended a silicon content of about 2 per cent. in the metal, much better results were obtained if the silicon was about half that amount.

Dr. Vanzetti had made a great point about the ability of the basic lined electric furnace to produce metal with very low sulphur and phosphorus contents. Although Mr. Deschamps was quite prepared to admit that converter steel, even when made under the best possible conditions, could not be made with as low sulphur and phosphorus contents as could be obtained in well-made basic electric furnace steel, it is now possible, by efficient desulphurisation of the metal issuing from the cupola prior to blowing, to obtain steel with a maximum of 0.04 per cent. sulphur even when the cupola charges contain as much as 70 per cent. steel scrap.

Regarding the phosphorus, it was admittedly an impossibility to remove it in the acid converter process, but too much importance was generally given to the presence of this latter impurity in the metal. After all, what mattered most to the foundryman was to obtain steel with the maximum fluidity for a given temperature, or, in other words, the maximum life, as Dr. Vanzetti had pointed out. Mr. Deschamps submitted that well-made converter steel evidenced this quality more than steels made by any other processes. That excellent physical results (unequalled by steel made by any other process) could be obtained had been proved by experience, and in this connection he pointed out that the existing specifications for steel castings were much too lenient and that instead of asking, as the present British standard specification does, for mild steel having a minimum tensile strength of 26 tons per sq. in., coupled with an elongation of 15 per cent. (which characteristics corresponded really to poor metal), we should insist that a minimum tensile strength of 26 tons per sq. in. be accompanied by a minimum elongation of 30 to 35 per cent.; that in the case of steel for wearing surfaces, where existing specifications ask for 35 tons minimum tensile coupled with a minimum elongation of 10 per cent. and no cold-bend test, we should insist on about twice this elongation and on a cold-bend test of at least 90 deg. without fracture.

He was satisfied that well-made converter steel could meet these more stringent requirements, and he expressed doubts as to the ability of steel made by any other process to equal these results. He championed the much-abused converter steel because he believed that there was still a great future for steel made by that process, the application of which had been considerably improved during the last ten years and which, in addition to its technical advantages, possessed another most important advantage, *i.e.*, cheap cost of manufacture. Many engineers considered that electric steel was the better metal, but he attributed this—to his mind erroneous—opinion to the glamour attached to the word "electric." In conclusion, Mr. Deschamps thanked Dr. Vanzetti again for his interesting statement on the Italian steel industry and expressed the hope that members of the Institute would have a further opportunity in the future to listen to him.

Claims of Electric Steel Supported.

Mr. W. B. Lake (Hon. Treasurer of the Institute and Past-President of the London Branch), in adding his thanks to Dr. Vanzetti for his very able Paper, recalled that some years ago, at a Foundry Convention in America, he had had the great privilege of accompanying Dr. Carlo Vanzetti on visits to a number of steel foundries and discussing with him the very questions which his son had dealt with so ably in the Paper. He was very much impressed by the lecture as a whole because he had felt that Dr. Vanzetti was dealing with realities and had put forward a number of figures which one could believe, for they had corresponded so well with figures he had obtained in actual practice.

Coming to a discussion of the merits of electric and converter steel, Mr. Lake said he felt that in attempting to cross swords with Mr. Deschamps he was attempting a very dangerous task, because he believed Mr. Deschamps had developed the manufacture of converter steel to a point to which few had developed it in this country. At the same time, Mr. Lake could not accept all that Mr. Deschamps had said on this subject, although he must make some allowances. He recalled his experience during the war when running a steel foundry engaged in the making of wheels for automobiles. These castings were particularly liable to hot cracks, and half the product was run from electric furnaces and half out of converter plant. The experience had been that in light and difficult castings there were many more tears and cracks when converter steel was used than when electric steel was used, but it was only fair to say that he had not used the desulphurising process, which had been introduced subsequently; if he had used it, the results might have been very different. He personally had never come across any converter steel which would give the same physical results as would electric steel. It might be that some of the later steels produced by Mr. Deschamps were better than electric steel, but he personally had tested steels made by a great number of foundries in this country and his tests had always shown that the well-made basic electric steel was the finest he had ever experienced so far as physical properties were concerned.

How Quality of Tropenas Steel has Improved.

Mr. P. Fassotte, although pleased that Mr. Lake had defended Dr. Vanzetti, said that he personally felt inclined to agree entirely with Mr. Deschamps' onslaught upon the theories developed by Dr. Vanzetti. He was most decidedly of the opinion, on the basis of the cost of current and the price of scrap which Dr. Vanzetti had indicated were ruling in Italy, that with proper converter practice he would make steel more cheaply. The proper course to take with regard to converter practice was to ignore the text-books, as they were completely out of date. During the last 10 years converter practice had been absolutely revolutionised in two essential respects—the economy of the process and the quality of the metal produced. It was a steel which, in the hands of the steelfounder, offered manifest advantages over any other type, and Mr. Lake must have been right in assuming that the converter steels which he had examined must have been made by the old method. The results which Mr. Deschamps had obtained were indeed exceptional, but they were not exceptional, perhaps, to the extent to which Mr. Lake believed them to be. In quite a number of foundries on the Continent and in this country nowadays, converter steel was being produced, day in and day out, of a quality absolutely undreamed of 10 years ago.

The factor which influenced to the largest extent the economic aspect of converter practice was, of course, the melting loss. With melting losses as high as 20 or 30 per cent., as indicated by Dr. Vanzetti, it was quite conceivable that the process would be expensive, but he could confirm that the results such as had been obtained by Mr. Deschamps, or at any rate results very near to them, were being obtained in other converter installations. The hot tears which Mr. Lake had experienced in the particular type of steel castings he had referred to were due, no doubt, to high sulphur content, because nowadays a hot tear was no more common in a converter foundry than in a foundry using the electric process. He personally had worked in a foundry having both electric furnaces and converters, but he had never experienced the difference to which Mr. Lake had referred. At this foundry, the converter was oil fired; every one of the foremen there, when they had to cast an intricate casting, preferred converter to electric steel. One of the reasons for that had been suggested to him by Mr. C. H. Kain, who had said that when electric steel was bad it was damned bad. That, in a way, confirmed what Dr. Vanzetti had said. Perhaps the position was best summed up by saying that it was more easy to make good converter steel regularly than to make good electric steel regularly; or, that one needed a really good operator to run a converter, and one needed an exceptionally good operator to operate an electric furnace. The discussion as to the merits of the two steels was really academic; in practice the whole question resolved itself into the quality of the operator.

Finally, he said that in a recent article Mr. Deschamps had expressed hopes about the rotary furnace in connection with steelmaking; nobody shared those hopes more ardently than he.

The Chairman, having seen the operation of the electric-steel furnace in Scandinavia and the converter process in England, said he had gained the impression that more labour was required in connection with the converter process than the electric process, and he asked what was the compensating factor which would enable cheap converter steel, as against electric steel, to be pro-

duced. Of course, much depended upon the cost of electricity in the case of the electric furnace.

A Message of Appreciation.

Mr. J. Cameron (Past-President of the Institute) took the opportunity to express to the London Branch the sympathy of himself and the Scottish Branch in the loss of Mr. Dews. He also took the opportunity to pay his personal tribute to the Vanzetti family, and to emphasise the value of the policy of the Institute in fostering valuable international associations. The late Mr. Oliver Stubbs, a President of the Institute, was one of the first British foundrymen to point out the good results which must accrue from these international friendships, and from the consequent interchange of views between foundrymen of various countries. In adopting that policy the foundrymen had set an example to the world, and it had been a great success. Mr. Cameron added that he had had the pleasure of knowing both Dr. Guido Vanzetti and his worthy father, Mr. Carlo Vanzetti. The International Foundry Congress and Exhibition at Milan in 1931 had been such a success, and Mr. Carlo Vanzetti had taken such a prominent part in connection with it that he had been honoured by his King; but a great deal of the work had been done by Dr. Guido Vanzetti, who had been guide, philosopher and friend to all who had attended. The Italian Congress would never be forgotten, and those who had attended would always recall with pleasure the hospitality extended to them. One important factor affecting the foundry industry in Italy was the lack of deposits of coal, and that, of course, had its influence on the adoption of the electric furnace. He recalled that at the Vanzetti foundry at Milan the production of cast iron was a sideline, and they had specialised in the production of an alloy having a wonderful resistance to corrosion, and which was used to some extent for making artistic ornamental figures for gardens, etc.

Bracketing Eliminates Cracks.

Mr. H. O. Slater supported Mr. Cameron's remarks concerning the policy adopted by British foundrymen in the direction of establishing and maintaining international friendships, and recalled that as far back as 1920-21, when he was President of the London Branch, a lecture was delivered to the Branch by Mr. Ronceray; he believed that this was Mr. Ronceray's first lecture in England. He recalled with pleasure the high quality of the lecture, and he believed that that was the first occasion on which the use of pencil runners in the making of castings had been mentioned in a lecture in this country; and there had been a very valuable discussion. Dr. Vanzetti, in his lecture, had well maintained the standard set by Mr. Ronceray years ago, and was to be congratulated upon it.

Discussing the references made to the merits of converter and electric steel, Mr. Slater expressed agreement with the view that much depends upon the skill of the operators of the furnaces, and added that much depended also upon the skill of the moulders. In this connection he related an experience concerning the casting of a steel smokebox for a railway engine. This casting was large, but very thin, and a number of cracks had developed in it. At first the steel was blamed, but after certain experiments had been carried out, by bracketing and so on, it was appreciated that the steel was not to blame. The method of making the core iron was altered, wood being incorporated in the place of loose iron rods in building up the cores, so that when the cores were dried the wood burned away to a large extent, the walls of the cores being made as thin as possible, and the interior filled with coke breeze, both wood and breeze made the cores almost collapsible, also greatly facilitating the removal of the main core iron, which was removed as soon as possible after casting. When that was done, and the whole of the brackets dispensed with, the casting was produced perfectly; that was a tribute to the skill of the moulder.

The Author's Reply.

Dr. Vanzetti, replying to the discussion, said that it was very difficult to compare figures obtained by the different processes of steel manufacturing, because there were so many variables entering into the problem. Moreover, that very good converter practice and electric-steel making were rarely found in the same foundry. Commenting on the references made to the importance of the skill of the operator, he said that this too introduced another variable into any comparisons made between converter and electric furnace; he pointed out that Mr. Deschamps was not able to run his electric furnace well enough, and no doubt Mr. Deschamps would insist that the founders at Milan were not able to run their converters satisfactorily.

With regard to melting losses, Dr. Vanzetti remembered that in his foundry the converter was used only in special cases, *i.e.*, for pouring large castings by the system described, which could not be poured by other processes because of the limited capacity of furnaces. For this reason, he declared, the steel had to be poured very hot from the converter as it had to be kept a few hours in the mixer. No doubt, he continued, other foundries that used the converter more generally had attained better results, but he did not think that many people reached the stage arrived at by Mr. Deschamps in connection with converter practice, by his long experience and skill. The labour costs depend upon the system of operation. At the Milan foundry, in order to produce large castings with two converters of one ton capacity, a special organisation was required, and therefore this method of running was rather expensive. They had tried to compare the costs when using a converter and an electric furnace in their own foundry, and had come to the conclusion that the costs for the actual melting of steel were about the same in each case, in spite of the high cost of electric power in that city. However, they found that unless the number of rejections of converter-steel castings were reduced, the advantage was with the electric steel.

Life Tests.

Replying to Mr. Deschamps, Dr. Vanzetti said that from the purchaser's point of view the mechanical properties of the steel were of course more important than the chemical ones, but that from a general point of view the chemical are no less important than the mechanical, as the latter may be said to depend on the former. As to the causes of tears and cracks in steel castings produced with the converter, Dr. Vanzetti did not think that these were due only to the sulphur content; figures had been given which showed that in an American foundry cracks and tears had developed in castings made from converter steel in which the sulphur content was less than that of electric steel from which castings free from cracks had been obtained.

Discussing the question of life, Dr. Vanzetti stated that one ought to compare the acid converter to the acid-electric furnace and not to the basic one, because the steel obtained from a basic furnace was not so fluid. He did not think it was altogether only a matter of temperature of pouring, as it seemed that there was in the acid steel a more rapid rising of the occlusions from the bath to the surface. But, he asked, was this increase in rising velocity the cause or perhaps only a consequence of the lower viscosity? It has also been asserted, according to the speaker, that the good life of acid steel was due to the fact that silicon *in statu nascendi* is more active and gives a better deoxydation.

Finally, Dr. Vanzetti expressed thanks to Mr. Cameron for his very kind words about the congress of Milan, and said that Italians had tried to accord to the English the same kind reception that they themselves had been given every time they visited England.

Vote of Thanks.

Mr. A. W. G. Bagshawe (Vice-President of the Branch), proposing a vote of thanks to Dr. Vanzetti, said the Paper was a very human one, and was of great interest to any ironfounder. He also congratulated Dr. Vanzetti upon having established throughout the Paper a reasonable balance between theory and practice, because that was something which we had been aspiring to for years, and Dr. Vanzetti had given a very good lead in that direction. He hoped that Dr. Vanzetti had gained information from the discussion in return for the information that he had given in the Paper, and looked forward to further opportunities of hearing lectures by Dr. Vanzetti in the future.

Mr. Deschamps seconded, and also expressed the hope that there would be further opportunities of meeting Dr. Vanzetti in the future.

The vote of thanks was carried with acclamation.

Dr. Vanzetti, responding, again expressed thanks for the reception accorded him, and assured the members that he had learned much that was of interest. Although it was of great value for him to be able to visit many foundries all over Europe and in America, and to hear the views of other foundrymen, he had actually only been working in the foundry for two years. It was because of his short practical experience that he had been rather diffident about accepting an invitation to deliver a lecture before masters of the art of founding.

The Discussion in Manchester.

The Chairman (Mr. Roy Stubbs) said this visit of Dr. Vanzetti's would go far to extend the activities of the Institute by co-operation with the Italian foundrymen. It was surprising that the Italian nation had worked itself up to the second place in the world's production of electric steel castings, particularly when one considered that all their pig and coal was imported from abroad. If they had those raw materials in their own country, they would make much greater progress.

Vote of Thanks.

Mr. E. Flower said the Lancashire Branch were honoured by the presence of Dr. Vanzetti, and he regretted that the approach of the first holiday of 1932 had lessened the attendance. He was surprised at the amount of time that Dr. Vanzetti gave to the advantages of the electric furnace compared with any other furnace. He then proposed that a hearty vote of thanks be accorded to Dr. Vanzetti for his lecture. Mr. J. Taylor seconded, and it was carried by acclamation.

Dr. Vanzetti said he came from a family of foundrymen, but it should be understood that it was only two years ago since he started with plant operation. He thanked the members for the kind reception they had given him, and he hoped to see them in Italy some time.

Life of Hearths.

Mr. E. Flower asked whether Dr. Vanzetti had any trouble with the refractory linings of the electric furnace. From conversations, he gathered that was a major trouble, as manufacturers were unable to find a refractory that would withstand the intense heat required for this class of furnace.

Dr. Vanzetti replied that they had used basic furnaces for many years, and were now experimenting with acid ones. They used magnesite bricks for the walls and silica bricks for the roof. They were now testing the efficiency of chromite for door jambs, but the results were not yet available. They did not have any trouble with actual lining, although some of their furnaces had conductive hearths.

Tundish Practice.

Mr. J. T. Parsons asked for further information on the subject of tundishes, and the steps they took when they met with a running stopper?

Dr. Vanzetti said that the use of an ordinary bottom-pouring ladle, if of 3 tons capacity, was liable to disturb the sand of the mould being cast and result in dirty steel. Therefore, to break the force of the stream they used a tundish.

Mr. Parsons explained that he once adopted the practice of filling hand shanks from a crane-suspended bottom-pouring ladle, but had discarded it, as he encountered trouble from running stoppers.

Dr. Vanzetti: In which way?

Mr. Parsons: The existence of a running stopper that could not be shut off.

Dr. Vanzetti said he used a graphite stopper and a fireclay nozzle.

Mr. Parsons asked whether such a thing as a running stopper was unknown in Milan.

Dr. Vanzetti said it happened very occasionally, but the German stoppers used were very good, and we rarely have any trouble with them, the exceptions being manganese steel. He often opened the stopper 180 times without any trouble when using a 3-ton ladle.

Mr. Parsons said they had great trouble with one furnace, and they had to shut it down three times within probably four months, yet they had had a second one running three years, which made 1,200 heats weighing 70 cwts. each.

Dr. Vanzetti said a furnace lasted about five months, working about six heats per day, equivalent to about 1,000 heats. It was about three tons every heat; so it was about 3,000 tons.

He also said if anyone present was using a converter he would be interested to know about the melting loss.

Melting Losses.

Mr. Masters said there were many points in connection with converters and melting loss. He recently had the pleasure of going through one of the largest converter plants in the country on a special job and he inquired what the melting loss was. It was given to him as 18 per cent. In one part of his Paper Dr. Vanzetti mentioned the desulphurising of metal and the rapid destruction of the linings of ladles used. What particular process of desulphurising did Dr. Vanzetti use?

Dr. Vanzetti said he used no process at all as the scrap available was low in sulphur, he had, however, referred to two processes—the Stoughton and the Scharlibbe.

Mr. Masters said the particular method he claimed to be conversant with was desulphurising in the ladle. One could claim to take 50 per cent. of the sulphur content out—that is, if the sulphur content exceeded 0.6 per cent.—for the purpose of casting into ingots for rail-making and the like. If the sulphur exceeded 0.06 per cent. it would not pass specification. In this particular process the metal was brought direct from the blast furnace in 20-ton lots and put into a producer gas-fired receiver or mixer which contained about 160 tons. It was rocked just to induce a modicum of mixing and also to absorb a certain amount of the radiation from the lining of the receiver by the metal. Unless a special lining was used for the ladle which conveyed the metal from the blast furnace to the mixer rapid erosion of the lining resulted and the desulphurising reagent did not act at all. Instead of having a sulphur reduction of 50 per cent. of the original content, it only gave about 10 per cent. or perhaps 15 at a maximum. By using a special neutral lining it resulted in a full 50 per cent. desulphurisation.

A Facing Development.

For the casting of green-sand moulds the addition of 1 per cent. of dextrine was said to be beneficial. He presumed it would give a good skin on the casting. That particular method had been developed the last four years, more so than it had ever been in this country before. Castings which up to four years ago were cast in dry-sand moulds were now being made much more economically. Castings were produced having a much better skin, and were apparently superior both physically and in general appearance than they were when made in the ordinary compo moulds. These moulds were made from a silica sand and a certain amount of binders which kept the mould rigid and seemed to protect its surface from erosion, yielding excellent stripping conditions. Some of the castings he had seen, which weighed as much as 4 tons, gave the impression that they had been made in grey iron. Finally he asked the nature of the sand used. Was it pure silica or argillaceous?

Dr. Vanzetti said that in Italy good sands were available for iron moulding but not for steel, due to their low fusibility. Normally French sands were used, such as the yellow sand from Coincy and the red sand of St. Hilaire. Their facing sand was prepared by mixing 70 to 75 per cent. of yellow sand and about 25 per cent. of old sand with about 3½ per cent. of water. The yellow sand they used contained about 90 per cent. of silica and about 10 per cent. of clay. What kind of testing apparatus did Mr. Masters use? Did he use the American Foundrymen's Association machines?

Mr. Masters said he used the British Cast Iron Research Association apparatus, and asked whether it was customary to dry the sand before mixing.

Dr. Vanzetti replied that as new sands obviously possessed a varying moisture content they preferred to dry it in order to institute standard conditions. In stainless-steel castings Bentonite was used, but as it absorbed moisture the moulds must not be left standing, as this binder was apt to absorb moisture.

Sand Preparation.

Mr. E. Longden said Dr. Vanzetti conveyed the impression that he laid very great stress on the type of furnace because of the difficulties of fuel supply. That was a question of economics, and the qualities of steel appeared to be more or less a secondary consideration in regard to the question of cost. The controversy raging round the qualities of steel would continue. They did not appear to have any real proof as to the values of the different methods of melting the steel.

The loss of steel during converting would mainly depend upon the process and class of metal used. In certain districts melting with the cupola and tropenas converter—duplexing—they were melting probably 75 per cent. steel, so that there would be the loss in the cupola prior to converting and they would also have a loss during converting. He would say that in England an average of 10 per cent. loss would be the case in practice. That was allowing for the loss of the elements in cupola and converter. He thought that was really the true situation. The 10 per cent. which was mentioned to Dr. Vanzetti in London did represent the average loss, he thought. Would Dr. Vanzetti enlarge a little on the value of sand in steel practice? In England, in up-to-date steel foundries, they attempted to clean the sand of silt. That was very important in steel foundry sands.

Dr. Vanzetti said they had in practice two systems. They used a dry process and also another system which was called washing the sand. They had used it for some time and were still using it. Some people used a suction system. His foundry had tried it and had had very good results. They used it especially for the sand coming out from the cleaning department; therefore it was yielding virtually a pure silica sand in the washing plant. They removed the burnt part and the recovered washed sand was utilised especially for cores. The sand was mixed with water and there was a sort of rake or scraper which pushed it up little by little along the inclined washing table, and the silt remained in the water and was separated from the good sand. The recovered sand was taken out from the top of the table. The whole of the water was pumped out into a large storage tank, where the clay and silt were allowed to settle out. This by-product was used in the foundry for secondary purposes.

Mr. E. Longden: It is the flotation process.

Mr. Vanzetti: Yes.

Mr. Longden said they were often asked to install various types of furnaces for melting grey iron. He did not suppose there were more than two or three electric furnaces in Great Britain melting grey iron. He believed in Italy a large number of furnaces were melting grey iron. It was a question of fuel costs mainly.

Dr. Vanzetti said that in his foundry for the last three years high-tensile irons were being made giving normally between 18 and 25 tons per sq. in.

The Imperial Chemical Industries Exhibition.

On Monday, Imperial Chemical Industries, Limited, opened an exhibition at Thames House, Millbank, S.W., primarily to show to architects the various materials they manufacture for the building industry. This is a commendable idea, and one which we trust will be followed by showing other industries just how they cater for them. We do not pretend to be cognisant of all the activities of this immense concern, but we are aware that they cater for the foundry industry by supplying limestone, non-ferrous alloys for remelting, welding apparatus, plastic wood, soda-ash, but there may be a multitude of other commodities. This particular exhibition is interesting to foundrymen from several angles. It shows plastic material both as a competitor of castings and its use in conjunction with them in the form of water-traps at the outlet of baths and washing-basins. A number of very well-formed letters made in some plastic material struck us as being excellent for pattern letters. The other department which has interest for the founder is that devoted to welding, even though it was confined to structural engineering. The exhibition will remain open to the public for a few weeks, and readers who happen to be in town during this period should certainly make a point of inspecting it.

Scottish Trade Mission Ship.

SOME OF THE EXHIBITORS.

The Scottish Trade Mission Ship, T.S.S. "Letitia," of the Anchor-Donaldson Line, is being equipped as a floating exhibition and will shortly leave for Montreal, where the Exhibition will be opened on Monday, May 16, remaining open until May 20. Among the numerous exhibitors who are showing their products in the Mission Ship are the following:—

Bonnybridge Silica & Fireclay Company, Limited, Bonnybridge; Bowie, W. T., & Company, Limited, Glasgow, S.E.; Braidwood Refractories, Limited; Castlecary Fireclay Company, Limited, Castlecary; Clyde Crane & Engineering Company, Limited, Mossend; Colvilles, Limited, Glasgow; Gartcraig Fire Clay Company, Limited, Glasgow; Glenboig Union Fireclay Company, Limited, Glasgow; Howden, Jas., & Company, Limited, Glasgow; Hurll, Peter & Mark, Limited, Glasgow; Lanarkshire Steel Company, Limited, Motherwell; Motherwell Iron & Steel Company, Limited, Motherwell; Peebles, Bruce, & Company, Limited, Edinburgh; Steel Company of Scotland, Limited, Glasgow; Stein, John G., & Company, Limited, Bonnybridge; Stewarts & Lloyds, Limited, Glasgow; Turnbull, Alex., & Company, Limited, Glasgow; United Collieries, Limited, Glasgow.

Making a Large Turbine Cylinder Casing Pattern.

By J. R. Moorhouse.

To build up the shape of a large turbine cylinder casing pattern with a ruling metal thickness of only 1¼ in., for powers of 50,000 kw. and over, require accurate construction in both pattern and core-box, if a uniform metal thickness be maintained. A shape that will permit of a basis of construction in the use of templates having two or more points of contact to work on are all to the advantage of the patternmaker. Figs. 1, 2 and 3 outline a development that allow for these conditions to be fulfilled.

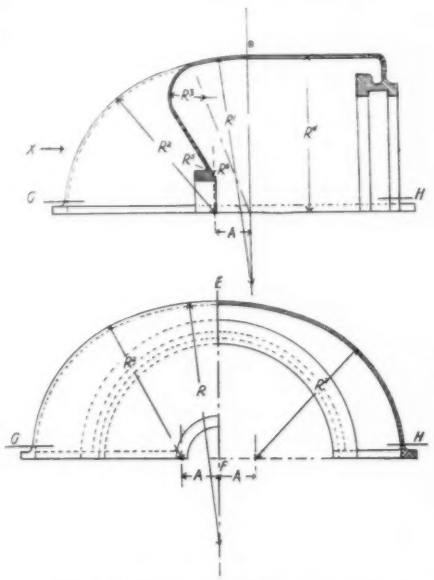

Fig. 1 (upper) and Fig. 2 (lower).

Fig. 1 shows a sectional side elevation through E, F; Fig. 2 a half-end elevation looking in the direction of X and a half-end section through B, C; and Fig. 3 is a half-plan showing the development of radii, and a section cut through G, H at the back of the flange. This shape of turbine casing also lends itself to

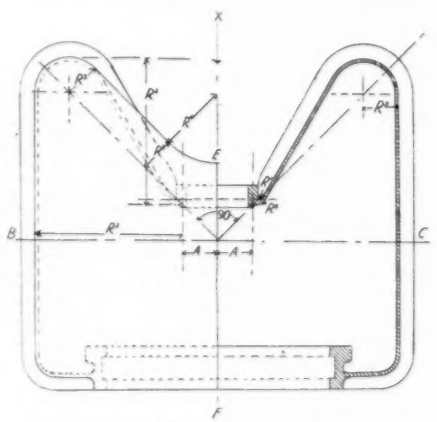

Fig. 3.—Half Plan showing development of Radii.

larger units by building the pattern in sections along the lines E F, B C and H G, and placing between sections the necessary extension parts.

To commence the pattern, it is first required to draw down to full contraction sizes the drawings, Figs. 1, 2 and 3. From these must be visualised the method of construction and the principle of developing the contour and radii of the pattern. A contraction of $\frac{1}{10}$ in. per ft. is allowed with $\frac{3}{8}$ in. to $\frac{1}{2}$ in. extra for machining where called for. All flanges must have an extra $\frac{1}{8}$ in. in thickness at the back, to provide for any probable distortion in the casting. It will help the patternmaker if the thickness of all coreprints and core joints, with the size and

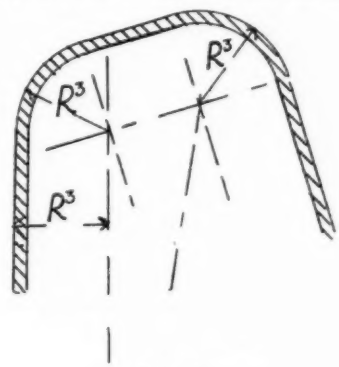

Fig. 3A.

position of the principle frame parts be included on the drawings.

A general idea of the method of construction, and the developing of the shape of the pattern, will become clear from a reference to Figs. 1, 2 and 3 in conjunction with Figs. 4, 5 and 6. It will be seen that the radius R3 is kept parallel to a base line (shown here as 90°) as it rounds the contour R2 till it meets the radii, R4 and R1. Lines radiate and form the hub-shape by cutting the radius, R3 at a tangent, and are continued until they meet the radius R5. If the pattern must have a flange-face opening, similar to Fig. 3A, the principle of construction will remain the same, providing the base of development has a common apex. A plan of a completed half-pattern is shown in Fig. 4, as is also a half-plan of the principle frame-members in position on the flange frame, preparatory to being lagged over. Fig. 5 is a side sectional elevation through the pattern showing the method of building the body part, and the means used for building in the hub portion.

Fig. 6 is a part half-section and elevation showing the method of bracing the frames, and a half-section end elevation showing the principle of staying and lagging the hub. Due to the size and weight of these patterns, a perfectly level floor or platform of sound construction for plumbing and assembling all frame parts must be laid down. On this is drawn the flange frame (*a*) and all principle frames. These are made off the lay-out, and the following must have attention to meet with foundry requirements:—

The coreprint (*b*) is usually made 4 in. thick, with a taper ¼ in. larger than the flange size at face opening. This requires to be dowelled on to the flange-frame member (*a*) for the purpose of bedding in the foundry floor, and for convenience in handling is jointed along the line M. The frame parts (*c*) are made right and left hand, and shaped to clear the hub lags in the manner shown in Fig. 6. The flange-frame member (*a*) is now located on the lay-out on the level platform, and temporarily secured in position. Care will be required in building all frame parts in correct relation to the base-line centre set at 90 deg., on which the frames (*c*) are firmly fixed and plumbed directly upon it.

For the purpose of being worked off to shape, the frames (*h*, *i* and *j*) are secured in position and developed in the following manner:—Two templates (*m*) are first built up off the drawing to agree with the contour R2. These are accurately located and plumbed up, so that the straight-edge (*n*) may be used to work across them and determine points in the process of construction to agree with the drawing. A template cut to agree with the radius R3 will use

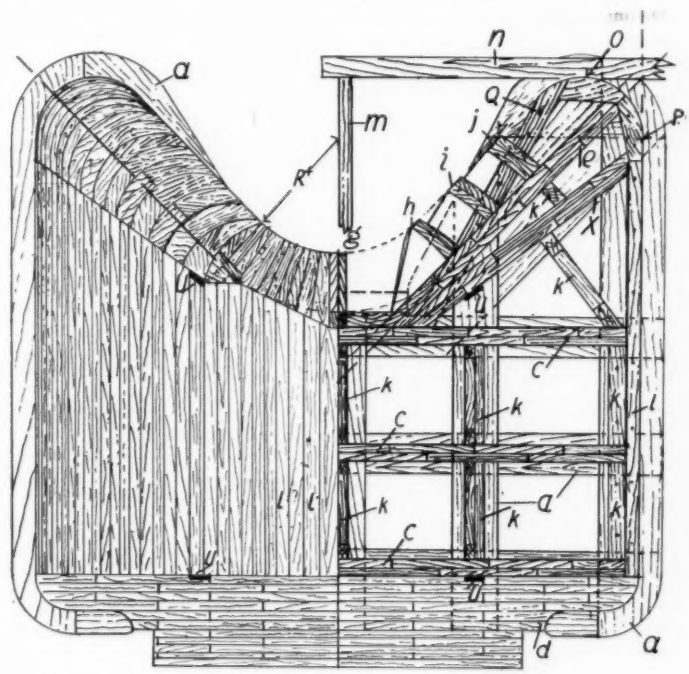

Fig. 4.

these points as one point of contact, the other being determined by a line parallel to the centre frame (*c*) and at a distance equal to R3. In this manner a curve is developed and formed at an angle of every 22½ deg. correct to drawing.

With the fitting of the stay-blocks (*s*), for the purpose of giving support to the lags Q, and the segments O, the framework of the pattern is complete. Four extra strong lifting-irons U, anchored under the flange and secured by bolts to the members (*c*), will be required for handling

the pattern. A reference to Fig. 4 show the manner of fixing the lags (*l*), for forming the body part of the pattern. The filling in of the hub is now proceeded with by fixing in the segments and lags between the frames (*h*, *i* and *j*), and working them to shape in the manner previously described with a template cut to agree with the radius R3.

From a point where the radius R2 intersects the radii R4 and R1, it is necessary to pick up points direct from the lay-out by means of a plumb line, to determine points of contact for the template R3 to work to. This completes the vital and difficult part of the pattern. A survey of the drawings, Figs. 4, 5 and 6, will show clearly the method of building the remaining details and their attachment to the pattern body. The method of developing the various radii being understood, it becomes a simple matter to follow the construction of the core box. From Figs. 7, 8 and 9 it is shown that in the construction of this core box the strickle is brought very much into use. To construct a complete core box may be desirable in the smaller

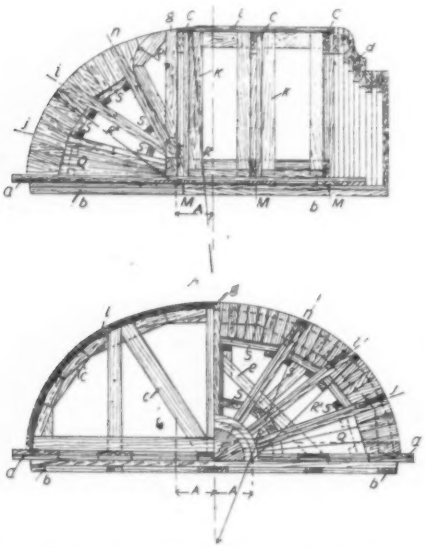

Fig. 5 (upper) and Fig. 6 (lower).

sizes of cylinder casings, but for large units they are unwieldy and difficult to maintain in shape, whilst the cost is prohibitive.

At Fig. 7 a plan of the core box is shown with the right-hand half complete, and the other half with the framework upon which are built the segments and lags for forming the hub shape. Fig. 8 is a side end elevation, and part section of the core box showing the method of lagging the hub portion of the core, and means used to develop the centre section of the core box, and Fig. 9 shows a half end elevation of the hub portion of core box, and also a half end elevation of the supporting framework, on which is developed the contour and radii to agree with the pattern shape. The principle overall dimensions are obtained by building two ends (*c*), braced together by stay pieces (*s*), between which will work the straight-edge strickle.

It is in the construction of the hub shape to conform to the pattern development that require explanation and direction in construction. It will be observed that the contour R2 *t*, and the radius R3 *t*, are formed in the core, in part, by the use of a straight-edge strickle working on the ends (*c*), a strickle (*m*), cut to a radius R3 *t*, and in part, by a shape worked in the hub timber, and developed on a base parallel, and at a distance equal to R3 *t* from the base-line centre.

To commence the construction, a frame (*l*) is built on the lay-out to conform to the shape and size of flange face opening, with a taper made to agree with the coreprint on pattern. To this is secured a frame (*a*) made to agree with a section, E, F, Fig. 3, taken on the centre line of the cylinder casing. These are then fixed and secured to the back frame (*e*), following the contour of the body less R3 *t*. This forms a surface on which the strickle (*m*) will slide.

It is now necessary to assemble all parts of the core box on the lay-out on the level

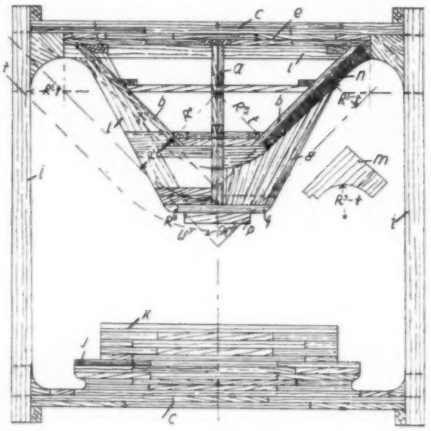

Fig. 7.

platform, plumb up and carefully check with the drawings. A straight edge placed across the ends (*c*) will determine points of contact for the template R3 *t* to work to. The other point of contact will be at a distance (*t*) from the base structure (*b*), Fig. 7, giving two known points along which the template will work in a radial manner to the centre

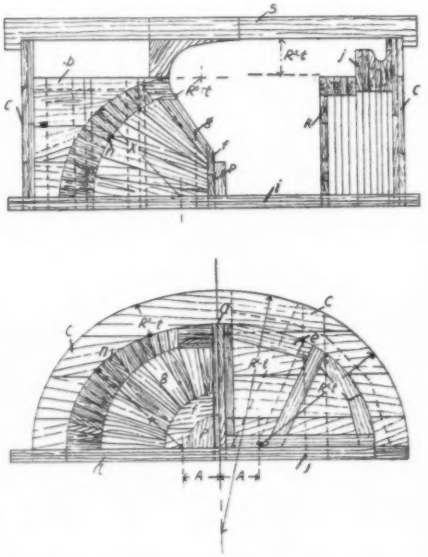

Fig. 8 (upper) and Fig. 9 (lower).

of R2 *t*. As each segment is fitted into position, it is marked with the metal thickness (*t*), and so jointed that their edges are radial to the centre R2 *t*. Along these edges the template is used to touch the point (*t*), and the straight-edge working across the ends (*c*).

In this manner a shape is constructed to form the hub that can be relied upon to follow the pattern shape with precision. At a point where the radius R2 *t* intersects the radius R4 *t*, the timbers are crossed in the manner shown and worked off to agree with the radius R4 *t*, and into the centre frame (*a*). With the filling in of the lags (*g*) and the segments (*n*), as shown, the most intricate part of the core box is completed. It only remains to make the guide strips to follow the line of development (*t*, *u*), shown in Fig. 7, to serve as a support for the strickle (*m*), and fill in the minor details, and the principle core box is complete. It remains to complete the core boxes for the coreprints (*k*), (*p*.). These follow the usual pattern-shop practice, and a further reference to all the drawings will show how these are arranged.

Catalogues Received.

Refined Pig-Iron.—The publicity department of Sir W. G. Armstrong, Whitworth & Company (Ironfounders), Limited, Close Works, Gateshead, is to be congratulated on the excellence of the production of their new 28-page catalogue dealing with "New Process Refined Pig-Iron." Not only is it attractively presented, but it contains the exact type of information which the modern foundry looks for. The brochure illustrates the plant which makes the iron; it illustrates an extremely wide range of castings which have been successfully made when utilising this "new process" pig-iron; it specifies the ranges of irons normally made, and illustrates their fracture, and details their physical tests and their composition. It contains a number of metallurgical tips on how to reduce costs through compositional adjustment; it details the sizes of pig and its supply in either sand or chill (machine) cast state. Then the compilers have stressed several times their ability and desire to supply pig-iron to the customer's analysis, whilst they also compile and issue a stock list of weights and analysis. As high-class pig-irons are not the easist thing in the wide world to smash, smallish pig is being made. We have seen in various works enormous "sows" of refined iron which could scarcely be used on account of their size, and this development of confining maximum length to 18 in. and 3¼ in. width will be appreciated. A covering letter kindly promises that our readers will be furnished with this brochure on application.

Steel and Pig-Iron. — Messrs. Colvilles, Limited, of 195, West George Street, Glasgow, have sent us an advance copy of a publication which details the various products of their gigantic organisation. A great change has taken place in the last decade or so, as prior to that time a firm manufactured a series of products which they detailed and it was left to the engineer to incorporate these in his designs. Now, the steelworks say, whilst our standard manufactures comprise this and that, we will supply any reasonable analysis and test requirements. So, too, with pig-iron. The brochure states that the firm manufactures and supplies such well-known brands as "Dalzell," "Glengarnock," "Clyde" and "Monkland," yet they are prepared to depart from these to meet customers' specifications. May we suggest that in future editions of this catalogue that the constituents should be placed in the order C, Si, Mn, S and P. This, of course, is a piece of general propaganda to get the pig-iron people generally to adopt the same order of "batting" as the steel industry. Whoever is responsible for the lay-out of this brochure is to be congratulated, as the best possible use has been made of the illustrations and matter. The photograph of the fracture of "Dalzell" special refined pig-iron, on page 26, is particularly interesting, as it shows the silver ring, which so many foundry managers very much esteem.

Following a meeting of the shareholders of Messrs. Bow, M'Lachlan & Company, Limited, shipbuilders, engineers and ironfounders, Thistle Works, Paisley, on April 26, it was announced that a resolution for the voluntary winding-up of the firm had been passed and a liquidator had been appointed.

Some Experiments on the Nitrogen-Hardening of Cast Iron.*

By J. E. Hurst (Sheffield).

The experimental results described in this Paper form part of an investigation of the degree of hardness obtainable and the general strength properties of aluminium-chromium cast iron suitable for nitrogen-hardening. The composition of the alloy cast iron is within the requirements of the commercial product known as Nitricastiron.

The material used in these experiments was taken from commercial casts of this alloy cast iron, for which the mixture is made up of refined chromium alloy pig-iron and returned scrap from previous casts of the same alloy. This mixture is melted in an oil-fired crucible furnace, and the requisite quantity of aluminium is added in the form of notched-bar to the molten mixture. Up to the present time the castings manufactured of this material have been principally cylinder liners cast by the centrifugal process.

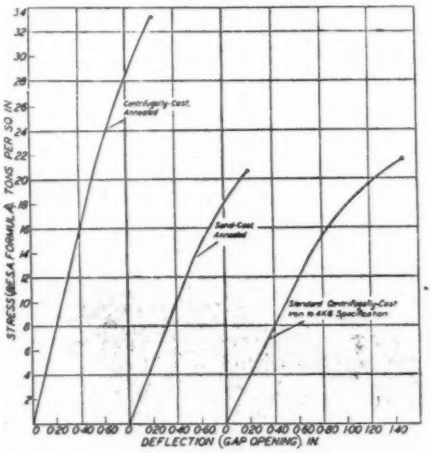
STRESS (BESA FORMULA) TONS PER SQ. IN.
Centrifugally-Cast, Annealed
Sand-Cast, Annealed
Standard Centrifugally-Cast Iron to 4K6 Specification
DEFLECTION (GAP OPENING) IN.

Fig. 1.—Stress-Deflection Curves.

Fig. 2.—Specimen No. 4, Centrifugally Cast. As-Cast etched with Picric Acid. × 200.

For this reason cylindrical castings were used for the test specimens, and the testing procedure was carried out on annular-ring-form specimens according to the methods defined in British Standard Specifications Nos. 5004 and 4K6 (aircraft material).† All the hardness determinations were made with the Firth hardometer, using the diamond indenter and a 30-kg. load.

Aluminium-chromium cast irons of the composition used have distinct air-hardening properties. The castings therefore are subjected to an annealing operation followed by slow cooling prior to machining. After rough-machining and prior to finish-machining the castings are preferably hardened and tempered. It has been found that in this condition the hardness obtained and the penetration of the nitrogen-hardening are better. For this treatment the castings are quenched in oil from a temperature of 850 to 875 deg. C. and tempered at a temperature of 600 to 650 deg. C. This tempering treatment is carried out in an electric resistance furnace, and is deliberately prolonged to combine the stabilising treatment intended to remove internal stresses and thus prevent distortion during the nitrogen-hardening treatment. The nitrogen-hardening treatment consists essentially of the exposure of the castings to the action of anhydrous ammonia gas at a temperature of 510 deg. C. for a period of 80 to 90 hrs. This process is carried out in a standard type of nitrogen-hardening furnace in a manner similar in every respect to the treatment of nitrogen-hardening steel.‡

For the examination of the general strength properties of aluminium-chromium cast-iron specimens at each stage of the preparation of the material for nitrogen-hardening, a number of cylindrical castings were made by the centrifugal process and also in green-sand moulds from the same melt of material. The castings in each case were identical in size, being made to the standard cylinder liner casting dimensions of 4.75 in. outside dia., 4 in. internal dia. and 10 in. long. Test rings of the dimensions required by the previously-mentioned specifications were machined from the castings and submitted to treatment. For the determination of the properties of the material in the as-cast condition test rings were turned off the castings prior to annealing. All chemical analyses were made on cuttings taken during the parting-off of test rings from the annealed castings. The test results on duplicate specimens for each stage of treatment are summarised in Tables I and II for centrifugal castings and sand castings respectively.

Table I.—*Cast No.* 147. *Centrifugally Cast Material.*
Mechanical Properties.

Specimen No.	Condition.	Treatment.	Modulus of elasticity. *EN* value. 10^6 lb. per sq. in.	Tensile strength. Tons per sq. in.	Modulus of rupture. Tons per sq. in.	Permanent set. Per cent.	Firth diamond hardness numeral.	Depth of Penetration of nitrogen-hardening. In.
3	As cast	—	22.5	24.5	39.2	2.56	418	—
4	As cast	—	22.5	25.9	41.5	N.D.	418	—
7	Annealed	950 deg. C. followed by slow cooling in furnace	22.5	31.5	50.4	2.78	302	—
8	Annealed		23.7	29.8	47.8	N.D.	302	—
11	Hardened and stabilised	O.-Q. from 870 deg. C., reheated to 600 deg. C. for 1 hr. followed by slow cooling in still air	23.0	29.5	47.2	4.75	302	—
12	Hardened and stabilised		22.7	31.4	50.4	N.D.	364	—
15	Nitrogen-hardened	90 hrs. at 510 deg. C. ..	24.8	28.9	46.3	N.D.	962	0.016
16	Nitrogen-hardened	90 hrs. at 510 deg. C. ..	23.5	29.8	47.8	N.D.	982	0.018
17	Nitralloy steel *LK*3	90 hrs. at 510 deg. C. ..		Control	specimen		1,066	0.026

Centrifugally-Cast Material.

The modulus of elasticity (*EN* value) is considerably higher at all stages of the treatment than that of ordinary centrifugally-cast material. Centrifugally-cast iron made to the requirements of the Aircraft Material Specification has an average *EN* value of 16 to 17 million lbs. per sq. in. The alloy cast iron has a minimum value of 22.5 and 19.5 million lbs. per sq. in. in the centrifugally-cast and sand-cast conditions respectively. This value changes slightly in the upward direction with each treatment. The nitrogen-hardened specimens have a distinctly higher *EN* value than the material in the as-cast condition.

Table II.—*Cast No.* 147. *Sand-Cast Material (Green Sand).*
Mechanical Properties.

Specimen No.	Condition.	Treatment.	Modulus of elasticity. *EN* value. 10^6 lb. per sq. in.	Tensile strength. Tons per sq. in.	Modulus of rupture. Tons per sq. in.	Permanent set. Per cent.	Firth diamond hardness numeral.	Depth of Penetration of nitrogen-hardening. In.
1	As cast	—	19.5	19.8	31.6	6.1	340	—
2	As cast	—	19.4	22.9	36.7	N.D.	340	—
5	Annealed	950 deg. C. followed by slow cooling in furnace	19.7	25.8	41.3	9.7	269	—
6	Annealed		19.7	N.D.	—	N.D.	262	—
9	Hardened and stabilised	O.-Q. from 870 deg. C., reheated to 600 deg. C. for 1 hr. followed by slow cooling in still air	19.2	28.6	45.7	N.D.	300	—
10	Hardened and stabilised		18.2	N.D.	—	N.D.	241	—
13	Nitrogen-hardened	90 hrs. at 510 deg. C. ..	20.1	N.D.	—	N.D.	894	0.015
14	Nitrogen-hardened	90 hrs. at 510 deg. C. ..	20.3	23.9	38.3	N.D.	904	0.015
17	Nitralloy steel *LK*3	90 hrs. at 510 deg. C. ..		Control	specimen		1,066	0.026

Analysis of Annealed Material.—T.C., 2.61 per cent.; Gr, 1.38; C.C., 1.23; Si, 2.58; Mn, 0.61; S, 0.07; P, 0.096; Cr, 1.69, and Al, 1.43 per cent.; V, trace; Ti, nil, and Mo, nil.

* A Paper read before the Spring Meeting of the Iron and Steel Institute.

† For further details of this testing procedure see J. E. Hurst, "Oil-Hardening and Air-Hardening Cast Irons," Foundry Trade Journal, 1930, vol. 43, p. 385.

‡ See W. H. Cunningham and J. S. Ashbury, "Journal of the Iron and Steel Institute," 1931, No. II, p. 215.

Analysis of Annealed Material.—T.C., 2.65 per cent.; Gr, 1.80; C.C., 0.85; Si, 2.44; Mn, 0.60; S, 0.075; P, 0.098; Cr, 1.58; and Al, 1.37 per cent.; V, trace; Ti, nil, and Mo, nil.

The strength values have been expressed as "tensile strength" in the terms of the previously-mentioned specification. For the sake of better comparison, these values are expressed also in terms of the modulus of rupture. Centri-

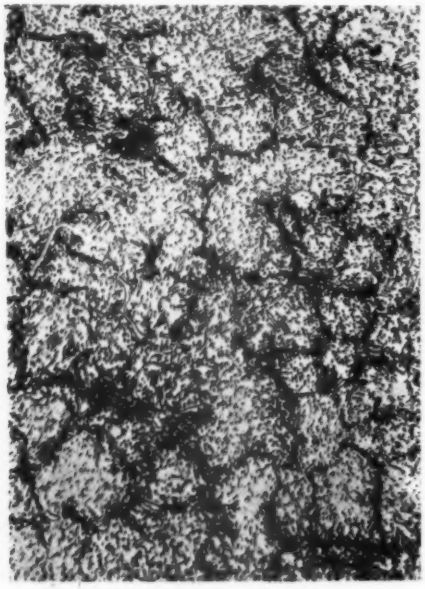

Fig. 3.—Specimen No. 8, Centrifugally-Cast-Annealed, etched with Picric Acid. × 200.

fugally-cast material to the 4K6 specification possesses average strength values of from 18 to 22 tons per sq. in., corresponding to moduli of rupture of 29 to 32 tons per sq. in. The strength of this aluminium-chromium alloy is therefore considerably higher than that of the ordinary centrifugally-cast material. The heat-treatment of the alloy is accompanied by a distinct increase in strength amounting to approximately 25 per

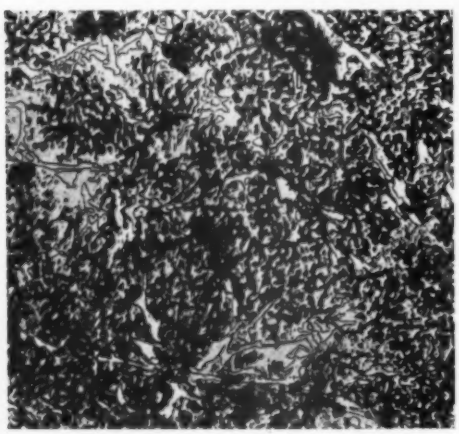

Fig. 4.—Specimen No. 12, Centrifugally Cast-Hardened and Stabilised, etched with Picric Acid. × 200.

cent. The nitrogen-hardened specimens show a slight falling-off from the strength level attained as a result of heat-treatment.

The permanent set is an arbitrary value commonly used in testing material for piston rings, cylinder liners and valve inserts, and represents the permanent change in the gap of a gapped ring after stressing at 14 tons per sq. in. (British Standards Institution formula). The values, which increase in the hardened and stabilised condition, are definitely low. Standard centrifugally-cast material usually shows a permanent set of the order of 8 to 10 per cent. The change in hardness of the material due to the heat-treatment is clearly indicated, annealing being accompanied by a distinct softening. Specimen No. 12 in the series shows a slightly higher value

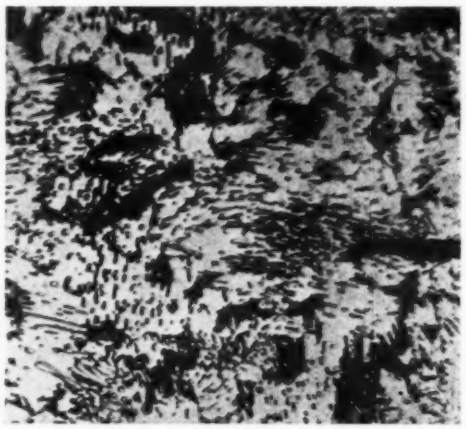

Fig. 5.—Specimen No. 5, Sand-Cast-Annealed, etched with Picric Acid. × 600.

than would be expected, due possibly to some slight irregularity in the treatment.

Sand-Cast Material.

The properties of the sand-cast specimens have approximately the same tendencies as those of the centrifugally-cast material. In magnitude the values of the modulus of elasticity (*EN* value) and tensile strength are lower than those

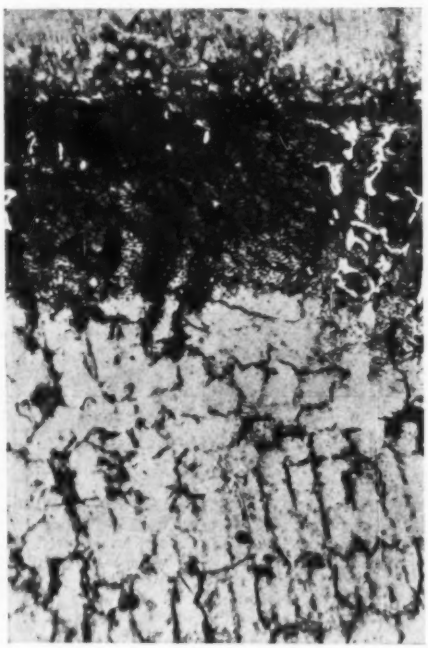

Fig. 6.—Sand-Cast Specimen, Nitrogen Hardened Depth 0.014 in., etched with Picric Acid. × 100.

of the same material centrifugally-cast; but at the same time they are distinctly higher than those of ordinary centrifugally-cast material, and quite equal to the best results obtainable with ordinary sand-cast iron for high-duty purposes. The permanent-set values are higher than those of the centrifugally-cast alloy and more nearly approach those obtained from ordinary centrifugally-cast material. In the as-cast and annealed condition the hardness is lower, but in the hardened and stabilised condition it more nearly approaches the hardness of the same alloy centrifugally-cast.

The sand-cast material is somewhat less stiff and less strong than the centrifugally-cast metal. This is illustrated further by the curves in Fig. 1, showing the relation between the stresses (British Standards Institution (formerly B.E.S.A.) formula) and the deflection (gap opening) of the annealed specimens of the sand-cast and centrifugally-cast material, respectively. For comparison purposes the curve of a similar specimen of ordinarily centrifugally-cast material made to the 4K6 specification is included.

Chemical Analyses.

The chemical analyses are typical of Nitricast-iron. The lower combined carbon contents of the

Fig. 7.—Centrifugally-Cast Specimen, Nitrogen-Hardened, Depth 0.010 in., etched with Picric Acid. × 200.

sand-cast specimens are due to the slower cooling of the metal in sand moulds. In the centrifugal-casting process metal moulds are used, and this would be expected to result in a higher combined carbon content. The higher combined carbon content in the latter specimens is evidently not destroyed by the annealing to which the specimens have been subjected.

The carbon determinations on the materials in the as-cast condition are given in Tables I and II. The slight change in the combined carbon and graphite due to annealing is shown by these results.

Machining.

The centrifugally-cast specimens are harder to machine than the sand-cast material. The annealed centrifugal castings were turned in the lathe at a speed of 70 ft. per min. with a depth of cut of $\frac{1}{4}$ to $\frac{5}{16}$ in. and a feed of 40 cuts per in., using Widia-tipped tools. The machining speed of the sand castings in the annealed condition was 90 ft. per min. with a depth of

cut of $\frac{1}{8}$ to $\frac{3}{16}$ in. and a feed of 30 to 40 cuts per in. with the same kind of tools.

Microstructure.

Figs. 2, 3 and 4 shows the etched microstructures of the centrifugally-cast specimens in the as-cast, annealed, and hardened and stabilised conditions, respectively. In the as-cast condition the matrix consists of very finely-laminated pearlite and extremely small graphite flakes, together with substantial quantities of free carbides. In the annealed condition (Fig. 3) the pearlite carbide is seen to have coagulated in a ferrite matrix. The finely-divided graphite is more clearly visible in this micrograph, and the free carbides are somewhat less in quantity. The hardened and tempered structure in Fig. 4 is that of specimen No. 12, which has a somewhat high hardness value for this condition. The matrix containing free carbide and graphite is presumably pearlitic in character, although it was found impossible to resolve this at a magnification of 1,500 dias. It was found to contain a large amount of small specks, which are probably carbides thrown out of solution during cooling. The dark-grey constituent is probably intermediate between troostite and pearlite, and this constituent is almost absent in specimen No. 11 possessing the lower hardness figure.

Fig. 5 shows the annealed specimen from the sand-cast sample No. 5; the coagulation of the pearlite carbide and the larger size of the graphite plates is revealed. The microstructures of the sand-cast specimens were similar to those of the centrifugally-cast specimens, with somewhat coarser graphite and a smaller amount of free carbide.

The Nitrogen-Hardened Surface.

For comparison purposes a standard specimen of Nitralloy steel *LK*3 was subjected to the nitrogen-hardening treatment along with the specimens of cast iron. The hardness and depth of penetration obtained are given in Tables I and II. The alloy, both when sand-cast and when centrifugally-cast, gave hardness and depth of penetration values somewhat lower than those of the control-steel specimen; the degree of hardness attained and also the depth of penetration in the centrifugally-cast specimens were slightly greater than those of the sand-cast specimens.

For the illustration of the structure of the hardened layer, micrographs have been chosen from several other specimens from the same cast of alloy material. Fig. 6 shows the structure of a sand-cast specimen, and Fig. 7 that of a centrifugally-cast specimen. The nitrogen-hardened layer in both cases etches darker than the core with picric acid. The carbides exist in the hardened case apparently undecomposed, and an extreme outer layer which etches lighter than the hardened case can be clearly seen under the microscope and is visible in Fig. 7. Fig. 8 shows the same specimen as Fig. 7 at a higher magnification. The extreme outer layer is clearly visible in this illustration, as are also the free massive carbides, the small specks of deposited carbides and the darker etching of the ground-mass constituents. It is of general interest to note that some of the massive carbide areas in the nitrogen-hardened portion show one or more rectilinear markings in a direction at right angles to their longest axis. None of the carbide areas in the core appears to show these markings. Immediately underneath the extreme outer layer is a concentration of specks of a third constituent. This appears to be characteristic, and a further example is shown in Fig. 9, illustrating the extreme outer edge of a sand-cast specimen. The depth of penetration of the hardening effect shown in Fig. 8 corresponds to the depth of the dark-etched case shown on the specimen at the lower magnification.

In all the specimens examined, the nitrogen-hardened surface is quite coherent and is not easily flaked or spalled. Under the microscope the polished surfaces of the hardened specimens show numerous small cavities. These are due to the presence of the free graphite in the surface and are illustrated in Fig. 10, which also shows a typical diamond hardness impression. The complete absence of spalling is demonstrated by this impression. The ring-form specimens used in the testing procedure are of rectangular cross-section, but in testing them no sign of flaking or spalling occurs even at the extreme corners of the section until stresses closely approximating to the breaking stresses are attained.

Fig. 8.—Same Specimen as Fig. 7, etched with Picric Acid. × 600.

Extreme outer layer (0.001 in.) occupies the 2nd $\frac{1}{2}$ in. at the top. Penetration (0.010 in.) finishes 7 ins. from the top, where the case merges into the core.

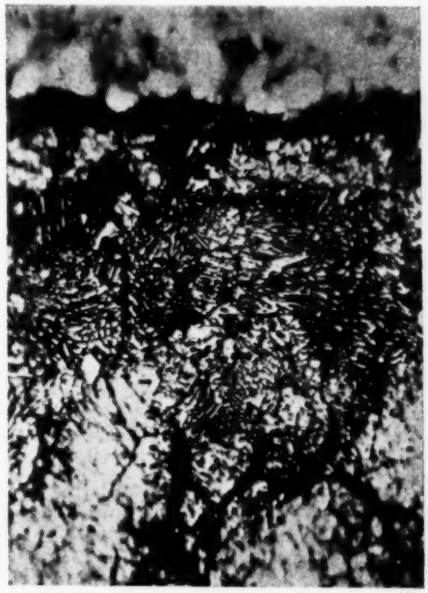

Fig. 9.—Sand-Cast Specimen, Nitrogen Hardened, extreme Edge of Case etched with Picric Acid. × 600.

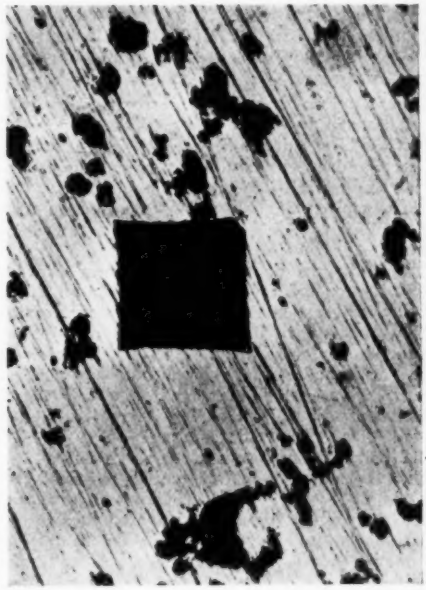

Fig. 10.—Diamond Hardness Impression on Nitrogen Hardened Surface of Centrifugally-Cast Sample, unetched. × 119.

Summary.

The properties of an aluminium-chromium alloy cast iron of a composition within the requirements of the commercial product Nitricast-iron have been examined. The testing procedure adopted has been mainly in accordance with that

laid down in the British Standard Specifications for piston-ring material, and tests have been made on centrifugally-cast and sand-cast specimens in the as-cast, annealed, heat-treated and nitrogen-hardened conditions. In the as-cast condition this alloy cast iron is shown to possess excellent strength properties. The modulus of elasticity (*EN* value) and Brinell hardness values are higher and the permanent set values lower than those usual for ordinary cast iron made to the requirements of the British Standard Specifications referred to. The centrifugally-cast material has a higher strength value, *EN* value and Brinell hardness, and a lower permanent set value, than the same material in the sand-cast conditon. In both the centrifugally-cast and sand-cast samples annealing is accompanied by a lowering of the Brinell hardness, an increase in the strength and permanent set values, and practically no change in the *EN* value. This alloy cast iron is susceptible to heat-treatment by hardening and stabilising, and with the treatment adopted the strength level and hardness attained in annealing are maintained.

The treatment of this alloy cast iron with ammonia gas under the conditions of the commercial nitrogen-hardening process is accompanied by surface hardening, and a diamond hardness value of 982 with a penetration of 0.018 in. was obtained in the centrifugally-cast specimen. In the specimens examined, the hardness and depth of penetration obtained were higher in the centrifugally-cast than in the sand-cast test-pieces and lower than in the control specimens of Nitralloy steel. The microstructures of the alloy material in each condition have been examined, and the coherence and freedom from spalling of the nitrogen-hardened surfaces demonstrated.

Permission to pubilsh these results has been granted by the directors of the Sheepbridge Stokes Centrifugal Castings Company, Limited, in whose laboratories these investigations were carried out. The author would like to take this opportunity of publicly acknowledging his thanks to them.

The Thermal Conductivities of Ingot Mould Irons.

Dr. J. W. Donaldson, D.Sc., in a contribution to the 4th Report on the Heterogeneity of Steel Ingots made by a joint committee of the Iron and Steel Institute and the National Federation of Iron and Steel Manufacturers to the Iron and Steel Industrial Research Council, states that the thermal conductivity of grey cast iron varies from 0.110 to 0.137 cal. per cm. per sec. and decreases as the temperature increases.

The influence of silicon is to lower the conductivity considerably, and manganese has a similar effect, although to a lesser extent. Phosphorus up to 0.80 per cent. tends to raise the conductivity slightly. As regards structure, free ferrite appears to be a much better conductor than eutectoid pearlite, owing to the relative conductivities of ferrite and cementite, which have been determined as 0.174 and 0.017 cal. per cm. per sec. respectively.

The thermal conductivity values obtained from the ingot mould irons are lower than those usually obtained from grey irons of similar compositions and structures, cast under ordinary foundry conditions, for engineering and other castings. This diminution in the heat-conducting property appears to be due to the nature of the irons, which are lacking in denseness and are of a more open nature than normal grey-iron castings. The thermal conductivity of these irons also appears to increase during the life of the moulds, due to the heat-treating or annealing influence of the molten steel on the material.

Rough grinding wheels can be prevented from clogging by rubbing with paraffin wax.

Institute of British Foundrymen.

ANNUAL CONFERENCE, NEWCASTLE-UPON-TYNE, JUNE 7 TO 10, 1932.

As previously announced the twenty-ninth Annual Conference of the Institute of British Foundrymen will be held in Newcastle-upon-Tyne, from June 7 to June 10.

It is eight years since the Annual Conference was held in Newcastle and members attending the Conference, who take advantage of the works visits, will be able to inspect some of the most modern foundry and engineering equipment in the British Isles. The route chosen for the Annual Excursion lies through some of the most lovely country, rich in historical associations.

The railway companies have again granted special concessions to Conference delegates, *single fare and one-third* for the double journey (fraction of 3d. reckoned as 3d.), upon surrender at the time of booking of the vouchers obtainable from the General Secretary. The tickets will be available from June 6 to June 11, 1932.

To facilitate arrangements it is particularly requested that the enclosed reply form, duly completed be forwarded to the General Secretary, St. John Street Chambers, Deansgate, Manchester, not later than Saturday, May 14.

The railway companies have granted the above facilities for reduced fares in return for a guarantee which has been given by the Institute for a minimum number of passengers. Members and ladies are particuarly requested in the interests of the Institute to avail themselves of this concession instead of making other railway arrangements, as, by so doing, they will help to increase the numbers, and so fulfil the guarantee. Members who live a short distance from Newcastle also are requested to avail themselves of these vouchers in preference to other railway arrangements. Should the guaranteed number of passengers not be reached it is possible that railway companies may decline to grant these privileges in subsequent years.

Programme.

Tuesday, June 7.

8.0 p.m.—General Council Meeting at the Station Hotel.

Wednesday, June 8.

9.15 a.m.—Conference opens in the Lecture Theatre of the Literary and Philosophical Society, Westgate Road (Ladies invited).

Civic Welcome by the Rt. Hon. The Lord Mayor of Newcastle-upon-Tyne (Alderman J. G. Nixon, J.P.); the President of the Newcastle and Gateshead Incorporated Chamber of Commerce (Rt. Hon. Lord Joicey), and the Principal of Armstrong College and Vice-Chancellor of the University of Durham (Sir William Marris, K.C.S.I., K.C.I.E., B.A., D.Litt.).

9.30 a.m.—Annual General Meeting, open to all members.

10.30 a.m.—Presidential Address. Mr. Victor Stobie, M.I.E.E.

10.50 a.m.—Discussion of Papers, Nos. 503 and 504.

12.30 p.m.—Conference adjourns.

12.45 p.m.—Luncheon at the County Hotel, Neville Street.

2.0 p.m.—Omnibuses leave Literary and Philosophical Society for the following works visits:—(1) The North Eastern Marine Engineering Company, Limited, Wallsend-on-Tyne; (2) A. Reyrolle & Company, Hebburn-on-Tyne; (3) Sir W. G. Armstrong, Whitworth & Company (Iron Founders), Limited, Close Works, Gateshead-on-Tyne; (4) The Priestman Collieries, Limited, Norwood Coke Ovens and By-Product Works, Teams.

7.0 p.m.—Annual Banquet, followed by Dancing until 1 a.m., at the Grand Assembly Rooms, Barras Bridge. (Evening dress optional.)

Thursday, June 9.

9.30 a.m.—Conference continues in the Lecture Theatre of the Literary and Philosophical Society. The following Papers will be presented and discussed:—Session A, Nos. 505, 506, 507; Session B, Nos. 508, 509, 510.

12.30 p.m.—Conference adjourns.

12.45 p.m.—Luncheon at the County Hotel, Neville Street.

2.0 p.m.—Omnibuses leave Literary and Philosophical Society for works visits:—(5) The Consett Iron Company, Limited, Consett; (6) Armstrong Saurer Commercial Vehicles, Limited, Scotswood Works, Newcastle-upon-Tyne; (7) Smith, Patterson & Company, Limited, Blaydon-on-Tyne; (8) Sir W. G. Armstrong Whitworth (Iron Founders), Close Works, Gateshead-on-Tyne.

7.30 p.m.—Civic Reception or Civic Reception and Dance by invitation of the Rt. Hon. The Lord Mayor and Lady Mayoress of Newcastle-upon-Tyne (Alderman and Mrs. J. G. Nixon). (Evening dress optional.)

Friday, June 10.

9.45 a.m.—Motor-coach to Hexham, visit to Roman Wall, luncheon at Hexham Hydro, continuing via Wark and Bellingham to Otterburn, visit Old Mill (1821) and Morpeth, afterwards via Elsdon to Rothbury, tea at County Hotel, returning Newcastle.

Ladies' Programme.

Wednesday, June 8.

9.15 a.m.—The ladies are invited to Official opening of Conference.

10.30 a.m.—Visit places of interest in the City.

12.45 p.m. Luncheon at County Hotel. (See General Programme.)

2.15 p.m.—Visit either of the following:—(9) "Newcastle Chronicle" Office, Westgate Road; (10) A. S. Wilkins, Limited, "Cremona" Toffee Works, Newcastle-upon-Tyne. (Omnibuses will convey ladies to the latter place.)

7.0 p.m.—Annual Banquet and Dance. (See General Programme.)

Thursday, June 9.

9.45 a.m.—Omnibuses leave Literary and Philosophical Society for Sunderland. Visit Preserve Works, luncheon at Sunderland, continue to Durham, visit Durham Castle and Durham Cathedral, tea at Durham.

7.30 p.m.—Civic Reception. (See General Programme.)

Friday, June 10.

9.45 a.m.—Motor-Coach Excursion. (See General Programme.)

Papers to be Submitted.

Wednesday, June 8.

Session A. No. 503.—*French Exchange Paper.* "Some Notes on Moulding and Pouring Practice," by J. Pillon. No. 504.—"Quantity Production of Grey Iron Castings," by J. O'Sullivan, Henry Ford & Son, Limited, Cork.

Thursday, June 9.

(Simultaneous Sessions will be arranged.)

Session A. No. 505—"Hardening Cast Iron—Hardened and Tempered and Nitrogen-hardened Cast Iron," by J. E. Hurst (Member), Sheepbridge Stokes Centrifugal Castings Company, Limited. No. 506—*American Exchange Paper.* "High Test Cast-Iron Developments in the United States," by R. S. MacPherran, Allis-Chalmers Manufacturing Company, Milwaukee. No. 507.—"Distortion and Camber in Castings," by E. Longden (Member), Craven Brothers, Limited, Manchester.

Session B. No. 508.—"Ferrous and Non-Ferrous Metals in the Foundry," by W. Rosenhain, D.Sc., F.R.S. No. 509.—"Some Lifting Considerations in a Jobbing Steel Foundry," by F. J. Hemming (Member), F. H. Lloyd & Company, Limited, Wednesbury. No. 510.—A Résumé of the Work of the Malleable Iron Sub-Committee of the Institute's Technical Committee.

Institute of British Foundrymen.

NEWCASTLE AND DISTRICT BRANCH.

At a meeting of the Newcastle and District Branch of the Institute, held at the Neville Hall, Newcastle-upon-Tyne, Mr. A. Sutcliffe, of Bolton, lectured upon the subject of "A Few Hours on the Floor of a Jobbing Foundry." The lecture was illustrated by lantern slides.

A brief synopsis of the lecture is as follows:—Quoting for jobbing work from sketches and drawings; description of sand used; the making of green-sand moulds; making elbow-pipe core; oil sand and loam with a very simple core iron; making loam work in skin-dried sand moulds, such as pan paint mixer, cone pulleys, clutch, etc.; talk on large bad castings.

Mr. Sutcliffe gave many instances of different jobs for which he had had to quote. In his opinion, many foundries were doing jobbing work at a loss in order to get work, and he thought that that was a great mistake. Mr. Sutcliffe had several samples of sand on view, and he expressed the opinion that the usual way of judging sand by crumbling it in one's hand was useless, and he showed how he judged it by pressing it together to make it stand and then slicing it with a knife. He said that he never milled any sand that had to be cast green. The floor sand which they used cost 3d. per hundredweight, and they used that for making any weight up to 12 tons.

The discussion was opened by Mr. Allan, the chairman, who asked Mr. Sutcliffe whether the moulds for the heavy wheels he had spoken of as being cast in a mixture of the two sands were dried at all. Mr. Sutcliffe replied that they did not dry any moulds whatever. Mr. Allan said that Mr. Sutcliffe had also mentioned the use of Glyso for facing parts of moulds where there were heavy brackets. He supposed the method would be to leave them standing overnight so that they would stiffen. Mr. Sutcliffe said that they had only taken a day to make; the pattern was removed by lunch time and it was cast at four o'clock. It was not machined in any way. Mr. Allan also said that he had often wondered to what weight of casting one could reach with an oil-sand core; he had never made anything heavier than two tons. He did not know whether Mr. Sutcliffe had had any experience of the type of job he had in mind—it was about 8 ft. long, cast on end and with a double flange, almost like a barrel. It was cast in oil sand with, he believed, Glyso-sand cores. The centre core was about 1 ft. 10 in. in dia., with four ribs running the full length of the core and the inside of the casting was as smooth and fine as if it had been made in loam. Mr. Sutcliffe said that it would be a body core and that there should be no trouble with it at all. Mr. Sutcliffe also suggested the addition of red sand to oil sand, which would thus give a better resistance to the metal. The gases would come away quite easily.

In reply to a question as to the percentage of oil in each sand, Mr. Sutcliffe said that the proportion of the linseed oil in the oil sand was 40 to 1; it was just ordinary sea sand. The "toffee" sand was just sea sand with Glyso. Mr. Frier asked where the sand got its colour from if it was just ordinary sea sand mixed with Glyso. Mr. Sutcliffe replied that it had been in the same mill as the others. Mr. Paulin asked what proportion of coal there was in that particular sand. Mr. Sutcliffe told him that there was none. Mr. Paulin said that in that case its blackness seemed to be an odd feature. He asked whether Mr. Sutcliffe found that milling the sand crushed it. Mr. Sutcliffe replied that the rollers did not touch the bottom of the mill.

Mr. Scott said that at the very beginning of his lecture Mr. Sutcliffe had talked of prices. It had interested him very much, because he had the same troubles. They often had to take work on at a price at which it was impossible to make a profit. They did that for two reasons, the first of which was that they learnt how to do that particular job and would probably be able to do it more cheaply the next time; the main reason, however, was that no matter whether they had any work or not, there were certain overhead charges which had to be paid and by taking work at reduced prices, they were able to contribute to those fixed charges. Referring to the 40-1 oil-sand mixture, Mr. Scott said that it seemed exceedingly weak. They made their oil sand in a proportion of 30-1; their oil-sand mixture was also 30-1, so that it was cheaper in one respect. With North-East Coast sand, a 30-1 mixture with linseed oil was necessary.

Mr. Sutcliffe said that he disagreed with Mr. Scott about the advisability of cutting prices to obtain work, because, after they had obtained the job, they would have to continue to do it at the reduced price.

Mr. Scott asked, with reference to the colour of the toffee sand, whether Mr. Sutcliffe thought there would be sufficient black sand in the mill to colour it like that. In his opinion, there was at least a 50-50 proportion of black sand in it. Therefore, Mr. Sutcliffe could not tell exactly what his mixtures were.

A vote of thanks to the lecturer was proposed by Mr. Shaw, seconded by Mr. Scott, to which Mr. Sutcliffe briefly replied.

The Institute of Metals.

MAY LECTURER.

The Twenty-second Annual May Lecture of the Institute of Metals will be delivered by Prof. Dr. F. Körber (Director, Kaiser Wilhelm-Institut für Eisenforschung, Düsseldorf) on Wednesday, May 11, at 8 p.m. at the Institution of Mechanical Engineers, Storey's Gate, Westminster, London, S.W.1, the subject of the lecture being "The Plastic Deformation of Metals." Cards of invitation to the lecture may be obtained from Mr. G. Shaw Scott, M.Sc., 36, Victoria Street, S.W.1.

Friedrich Körber studied mathematics, physics and chemistry at the University of Göttingen and Münich. He received his degree of Dr.phil. in 1909, as a result of work on physical chemistry, which was sponsored by Prof. G. Tammann, Göttingen. Afterwards he was assistant at the Physical Chemical Institute at the University of Göttingen until the outbreak of the war. From 1917 to 1920 he was lecturer in physical metallurgy at the Technical High School, Aachen. In 1920 he went to the Kaiser-Wilhelm Institut für Eisenforschung, in Düsseldorf, as departmental director, and became its director in 1922. He was given an honorary degree of Doctor of the Technical High School, Dresden, in 1929, and was elected honorary Professor of the Technical High School, Aachen, in 1929. His chief work is connected with the physical chemistry of metals, especially iron and steel, and with processes of production of steel. He has done much work on the testing of materials and on the examination of the properties of iron and steel. He is a member of the Deutschen Verbandes für die Materialprüfungen der Technik, of the Verein deutscher Eisenhuttenleute, and of the Institute of Metals.

Kelvin Medal, 1932.—The Kelvin Medal Award Committee, after consideration of representations received from leading engineering bodies in all parts of the world, have awarded the Kelvin Medal for 1932 to the Marchese Guglielmo Marconi. The Kelvin Medal is awarded as a mark of distinction in engineering work and investigation of the kinds with which Lord Kelvin was especially identified. This is the fifth triennial award of the Medal, which has in previous years been given to Dr. W. C. Unwin, F.R.S. (Great Britain), Prof. Elihu Thomson, D.Sc. (U.S.A.), (the late) the Hon. Sir Charles A. Parsons, O.M. (Great Britain), and M. André Blondel (France).

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Mould Stoves.

To the Editor of The Foundry Trade Journal.

Sir,—With reference to the criticisms published in your last issue relative to my letter of April 25, may I point out that the "time" element was taken into consideration, as a period of one night is definitely specified. Under these circumstances, it would seem that the efficiency can be measured by the quantity of fuel consumed per lb. of water evaporated.

I fully appreciate that it is quite possible to have a stove thermally efficient, yet burning the moulds; but in writing on this subject I assumed that it would be taken for granted that the moulds would not be burnt.—Yours, etc.,

Norman G. Calder.

Thomas E. Gray & Company, Limited,
119, High Holborn,
London, W.C.1.

April 29, 1932.

Refractories for Rotary Furnaces.

To the Editor of The Foundry Trade Journal.

Sir,—In your last issue you describe, under the heading "Notes from I.B.F. Branches," a visit by the Sheffield Branch of the Institute of British Foundrymen to Messrs. Clegg & Howgates, Limited, Bingley. In it there are several points that require correction and elucidation. (1) Our name was incorrectly spelt; (2) a statement by Mr. Howgate regarding outlet end of the furnace having given 400 heats is perfectly true, but it is by no means clear that the lining was also supplied by us, and (3) you continue to say the lining of the front part of the furnace was of English ganister supplied by, etc., and we feel sure that the following should be noted, as there is a marked difference in the materials, viz., our material is four raw products mixed together in a manner peculiar to the nature of the bonding material which is being used. Certainly ganister is included, but the secret is not the ganister, which of course is of a high quality, but more particularly the bonding material, and it will therefore be more correct and perhaps more interesting to your readers to refer to this lining as being a highly refractory mixture for withstanding excessive erosion conditions, giving, as is definitely proved by the Brackelsberg furnace, as a whole, a longer life than any other material which is at present being supplied by British refractory people such as ourselves, from only English deposits.

The success achieved is such that Brackelsberg furnace-owners abroad have found it of interest to ask for substantial samples for testing purposes, so that when domestic owners of rotary furnaces are called upon by sellers to use a foreign lining on account of its superior qualities, they can rest assured that they are not only being misled, but are being asked to strengthen the grip that foreign countries already possess in the development of these rotary furnaces in the United Kingdom.—Yours, etc.,

G. P. Hinckley
(J. Hinckley & Son).

11, East Parade Chambers,
Sheffield.
May 2, 1932.

The Power Gas Economy Company, Glasgow, has just received the following orders:—Messrs. Dorman, Long & Company, Limited, Cleveland Ironworks, for complete gas-firing equipment, including automatic air regulation, for six Babcock boilers, making the fourth order, covering 20 boilers, during the last 18 months at this works; Mines de Lens, France, a fourth order, for an installation of coke-oven gas burners using hot air under pressure; G. Bailly Mathot, Belgium, an installation of coke-oven gas burners, also a fourth order.

This Week's News in Brief.

Trade Talk.

Messrs. Thos. W. Ward, Limited, are removing their London office from 116 to 90, Fenchurch Street, E.C.3.

Messrs. W. T. Henley's Telegraph Works Company, Limited, has opened a new stores depôt at 37, Magdalen Road, Exeter.

Messrs. Henry Robb, Limited, shipbuilders, Leith, have secured an order for a motor coaster for service in the South of England.

The "Lionweld" Steel Flooring & Stairway Company is to build an extension to its present works in Marsh Road, Middlesbrough.

We regret to record that, through an explosion around the oxygen plant at the Darlington Forge, one fettler, William Miller, was killed and three others are seriously injured.

The Mersey Docks and Harbour Board has accepted the tender of Messrs. Cammell Laird & Company, Limited, Birkenhead, for the building of a dredger at the cost of £103,000.

We are informed by Messrs. Thos. E. Gray & Company, Limited, High Holborn, London, W.C.1, that they have discontinued the representation of Messrs. Zimmermann & Company, of Düsseldorf, manufacturers of moulding machines.

Messrs. Smith's Dock Company, Limited, Middlesbrough, last week launched four whaling vessels for Norwegian owners. A contract for the reconditioning of 12 whaling vessels has been secured by the company.

Through the fall of the roof in the Caledonia Foundry, Shuna Street, Maryhill, Glasgow, two iron-dressers were injured. The men were not seriously hurt, and were permitted to proceed to their homes after receiving attention in the infirmary.

All the men employed by Messrs. Colvilles, Limited, at their Clydebridge works, Cambuslang, were recently paid off, but a welcome development took place on April 26, when the plate mills, cogging mill and shears were restarted and two 65-ton melting furnaces put into operation.

The balance sheet of the Hauts-fourneaux de Saulnes (Jean Raty & Cie) shows for 1931 net profits totalling 15,036,694 fcs. (as against 22,593,426 fcs. in 1930). The directors recommend the payment of a dividend at the rate of 60 fcs. gross for last year, as compared with 100 fcs. in 1930.

British Moulding Machines, Limited, of 237, Weston Street, Tooley Street, Bermondsey, London, S.E.1, announce that they have been appointed British agents for the Gustav Zimmermann Engineering Works of Düsseldorf for the sale of their well-known moulding machines. Arrangements are being made for manufacturing in Great Britain.

The partnership between Messrs. William Harris, Edwin Adams, Arthur Nock, J. T. Tibbets and Lucy Harris, carrying on business as iron founders, at Blackheath, under the style of the British Malleable Iron Company, has been dissolved, Mr. Adams and Mr. Nock having retired from the firm. The remaining partners are continuing the business under the same style.

At an extraordinary general meeting of the Aston Brass Company, Limited, held at 36, Queen Annes Gate, Westminster, S.W.1, on April 20, resolutions were passed "that the company be wound up voluntarily," Mr. C. J. Pereira, 73, Cheapside, London, E.C.2, being appointed liquidator, and that a provisional agreement for the transfer of the undertaking to the Valor Company, Limited, be approved and the liquidator authorised to carry it into effect.

New Companies.

Williams, Alexandra Foundry, Limited, Alexandra Foundry, East Dock, Cardiff.—Capital £1,000. Brass founders. Director: W. Williams.

Hounslow Castings, Limited, Inverness Works, Inverness Road, Hounslow.—Capital £500. Metal founders. Directors: M. Dewhurst and J. Brook.

Ferbrite, Limited.—Capital £1,100. Metallurgical processes. Solicitors: Kenneth Brown, Baker, Baker, Essex House, Essex Street, London, W.C.

Drake Foundry & Engineering Company, Limited, 11, Priory Street, Coventry.—Capital £300. Directors: G. H. and Mrs. L. Drake, Mrs. I. G. Wade.

Personal.

Mr. John Henry Pease, formerly managing director of the Normanby Ironworks of Messrs. Pease & Partners, Limited, Darlington, has been appointed a county magistrate.

Mr. C. D. Pollard, the President-Elect of the Sheffield Branch of the Institute of British Foundrymen, has changed his address to "Belmont," Avenue Vivian, Scunthorpe.

Mr. R. J. Walker, chairman and managing director of Messrs. Parsons Marine Steam Turbine Company, Limited, Wallsend-on-Tyne, has been elected President of the North-East Coast Institution of Engineers and Shipbuilders.

Mr. Summers Hunter, until recently chairman and managing director of the North-Eastern Marine Engineering Company, Limited, Wallsend, was presented with the diploma of honorary fellowship of the North-East Coast Institution of Engineers and Shipbuilders at a meeting in Newcastle on Friday, April 22.

Mr. Alexander B. Lochart has just retired after 60 years' service with the Lennox Foundry Company, Alexandria, Dumbartonshire. He had been foreman moulder in the foundry for over 30 years, and during his long service witnessed many changes in the trade. Prior to his leaving on April 29 Mr. Lochart received a presentation from his fellow-workers.

Viscount Falmouth, who in June last undertook the charge of the works of the English Steel Corporation, Limited, at Sheffield, has requested to be relieved of that appointment on account of his other engagements. He has agreed to become deputy-chairman of the Corporation. The directors have appointed Commander C. W. Craven, managing director of the works and shipyards of Messrs. Vickers-Armstrongs, Limited, to be managing director.

Sir Roland Nugent tendered his resignation of the post of Director of the Federation of British Industries at a meeting of the Grand Council of the Federation on April 27, owing to increasing pressure of private interests. The resignation was accepted with regret, but satisfaction was expressed at the fact that the Federation would not entirely lose Sir Roland's services, since arrangements had been made whereby he would be able to act, as occasion required, in an advisory capacity. At the same meeting the Council unanimously approved of the appointment of Mr. Guy Locock as Acting Director of the Federation. Mr. Locock has served the Federation for 14 years as Assistant Director.

Wills.

Stevenson, L. R., of Oxton, Birkenhead, retired iron merchant	£35,549
Maxwell, W. R., of Glasgow, a director of Messrs. Nielson & Maxwell, Limited, iron and steel merchants, Glasgow	£51,232

Obituary.

Mr. James Lindsay Twaddell, J.P., late general manager of Messrs. Palmers Shipbuilding & Iron Company, Limited, Jarrow Works, died on Friday, April 22, at the age of 75. He was manager for 19 years, retiring at the end of the war.

We regret to announce the death of Mr. L. W. Spring, chief chemist to the Crane Company, of Chicago. Last year he presented the annual Exchange Paper on behalf of the American Foundrymen's Association to the Institute of British Foundrymen. He was picked out last January as the next recipient of the American Foundrymen's Association Gold Medal.

The death occurred at Burntisland, on April 28, of Mr. M'Kenzie Dallas, superintending engineer of Carron Company. Mr. Dallas had been unwell for some time, and underwent an operation in February last. He was only 44 years of age, but regarded as one of the most capable departmental heads in the service of Carron Company, and was in charge of many important extension schemes since joining the firm in 1922. In his early days Mr. Dallas went to sea and held a first-class B.O.T. engineer's certificate. During the war he served as engineer-in-chief on H.M.S. "Fox," and after demobilisation became associated with Messrs. Allsop, Burton-on-Trent.

Contracts Open.

Aberewmboi, May 9.—2,460 yds. of 32-in. dia., 98 yds. of 36-in. dia. and 1,700 yds. of 38-in. dia. cast-iron pipes, for the Aberdare and Mountain Ash Urban District Councils' Joint Committee. Messrs. Thomas & Morgan & Partners, engineers, Pontypridd. (Fee £10, returnable.)

Cairo, May 28.—Iron and steel stores, for the Egyptian Ministry of Public Works. The Department of Overseas Trade. (Reference G.X. 11,424.)

Cork, May 21.—5,400 ft. of 3-in. and 1,233 ft. of 6-in. dia. cast-iron pipes, and specials, for the Town Council. The Waterworks Office, Fitzgerald Park, Cork. Mr. C. Harrington, town clerk, Town Clerk's Office, Fitzgerald Park, Cork.

Koussieh, May 28.—100 water meters, for the Ministry of the Interior. The Department of Overseas Trade. (Reference G.X. 11,427.)

Norwich.—10-in., 12-in. and 15-in. high-pressure steam piping and 30-in. cast-iron pipework, for the Electricity Committee. Mr. F. M. Long, city electrical engineer, Corporation Electricity Works, Duke Street, Norwich.

Rosetta, May 28.—185 water meters, for the Ministry of the Interior. The Department of Overseas Trade. (Reference G.X. 11,426.)

Sandown, May 9.—Two vertical centrifugal pumps, for the Urban District Council. The Engineers, Town Hall, Sandown, I.W.

Whitby, May 9.—Centrifugal pumps, with motors, etc., for the Urban District Council. Mr. J. R. Seward, surveyor, Council Offices, Whitby.

Wymondham, May 14.—Duplicate pumping plant, for the Forehoe Rural District Council. Mr. A. J. Martin, 108, St. George's Square, Westminster, S.W.1. (Fee £5, returnable.)

Thermal Properties of Ingot Mould Irons.

(*Concluded from page* 273.)

Conclusions.

As a result of their tests the authors draw the following conclusions:—

(1) Chemical analyses of moulds from various sources show that, while there are variations in the total carbon and silicon, on the whole they conform to a generally-accepted composition; lesser variations may occur from one part of a mould to another.

(2) Microscopic examination shows that moulds are substantially pearlitic as cast, interspersed with flake graphite. The size of the individual flakes of graphite varies considerably from mould to mould, and may also vary from one part of a mould to another.

(3) The density of ingot mould iron decreases as the total carbon and silicon contents increase, and, of course, decreases as the temperature rises.

(4) The electrical resistivity increases with an increase of the total carbon and silicon.

(5) There is little variation in the critical points on heating and cooling or in thermal expansion. The capacity for permanent growth varies from iron to iron.

(6) During its life, the composition of the mould metal changes slightly. The total carbon falls, due to decarburisation at the working face, and the combined carbon falls, due to the conversion under heat of pearlite to ferrite. These changes are, of course, greatest at the working face and least on the outside. They produce a consequential decrease in density.

(7) There is no direct correlation between the composition and physical properties, these being also determined in part by the structure, which in turn is governed partly by the conditions of melting. In view of the variety of graphite structures obtainable, there seems little likelihood of establishing direct correlation between the physical properties and the constitution, including both the composition and the structure.

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Raw Material Markets.

Although the new tariffs have imparted considerable confidence to the market, there is as yet no increase in the actual amount of business transacted, owing to the large stocks of foreign material held in this country and to the fact that Continental steel is in many cases still competitive with the home product. In the pig-iron market there is an increase in the demand for foundry iron, more forward contracts in particular being arranged. Sales of hematite also show improvement. On the other hand, business in finished steel remains slow. There is also little demand for tinplates and galvanised steel sheets.

Pig-Iron.

MIDDLESBROUGH.—The position in this market has slightly improved, several sales being negotiated to Scotland. Local deliveries continue to be on a fairly good scale, but the export position is unfavourable. Special rebates are offered to Scotland, but to all other destinations prices are:—No. 1 Cleveland foundry iron, 61s.; No. 3 Cleveland G.M.B., 58s. 6d.; No. 4 foundry, 57s. 6d.; No. 4 forge, 57s. per ton, f.o.r. or f.o.b.

The future of the East Coast hematite market is more promising, owing to the additional protection granted the steel industry, but the prompt position shows no improvement, as large stocks are being offered on the market. Hence it is still possible to obtain East Coast mixed numbers at 63s. 6d. per ton, with 6d. extra for No. 1 quality. There is a fair demand for West Coast mixed numbers, but mostly of a hand-to-mouth character, the price remaining at 66s. per ton at works.

LANCASHIRE.—The foundry-iron market has exhibited a rather cautious aspect during the past week. Slow conditions prevail at the general foundries, and the makers report no sign of expansion in deliveries. One or two odd orders have been booked for delivery over the next few months. There has been little change in prices, offers of Midland brands—Derbyshire and Staffordshire—for delivery in the Manchester district being at 67s. per ton, with North-East Coast No. 3 also at 67s., Northamptonshire at 65s. 6d., Derbyshire forge iron at 62s. 6d., West Coast hematite at about 81s., Scottish foundry at 86s. 6d. to 87s., and Indian pig-iron at 75s. to 77s. per ton.

MIDLANDS.—Mainly owing to the possibilities arising from the new tariffs, more consumers have been on the market, and there has been a slight increase in the turnover. Many of the ironfounders, however, are already covered for some distance ahead. It is also reported that the stocks at the makers' works have been considerably increasing lately. Quotations, including delivery to Birmingham and Black Country stations, are 62s. 6d. for Northants No. 3 and 66s. for Staffordshire, Derbyshire or Lincolnshire No. 3.

SCOTLAND.—The depression in the Scottish pig-iron market remains unrelieved. Many of the heavy engineering foundries are closed down altogether, and others are only working two or three days per week. No. 3 Scottish foundry iron remains at the official minimum of 69s. 6d. per ton at furnaces, with 2s. 6d. extra for No. 1. No. 3 Middlesbrough continues at 58s. 6d. f.o.t. Grangemouth, other English irons being slightly less.

Coke.

There is practically no forward buying of foundry coke, the ironfounders being content to satisfy only their immediate needs. Prices are unaltered at 37s. 6d. to 40s. delivered Birmingham district for best Durham grades, with cheaper qualities at about 2s. 6d. less, and 30s. to 45s., according to quality, for Welsh coke.

Steel.

Sales of finished steel do not show any improvement, those who are normally the heaviest consumers being unfortunately the shortest of work at the moment. The new tariffs will, of course, affect the situation, but it is estimated that at least six months must elapse before present stocks of foreign material are exhausted. There is also still a considerable difference between the British and Continental prices of small steel bars. Sellers of Continental semi-finished steel have also a price advantage of some shillings in all areas. Few orders for semis have been given out by consumers, however, the majority being very well stocked.

Scrap.

There is, as yet, no improvement to record in the state of the Cleveland scrap iron market. Ordinary heavy foundry metal is obtainable at 38s., while no more than 40s. can be realised for good machinery cast iron in handy pieces. Light castings are weak at 35s. In the Midlands, cast-iron scrap is in slightly better demand. Machinery metal, broken into cupola sizes, is offered at 47s. 6d. delivered, good heavy at 42s. 6d. to 45s. delivered, and clean light cast iron at 37s. 6d. to 40s. delivered. In South Wales, some business has been done in heavy cast iron in large pieces and furnace sizes at about 45s. The Scottish market remains inactive and prices are largely nominal.

Metals.

Copper.—The standard market has remained steady but dull during the past week. Consumers in this country have been buying spasmodically, but sales on the Continent remain at a low level. The official quotation for Customs metal has remained at 6 cents, but this figure is still being underquoted by outside interests, who are securing most of the business. There has been no improvement in consumption in the United States. Great Britain, on the other hand, has now become second in the list of copper-consuming countries, Germany having already lost that position this year. America, of course, still remains at the top of the list.

Closing quotations :—

Cash.—Thursday, £30 1s. 3d. to £30 2s. 6d.; Friday, £30 1s. 3d. to £30 2s. 6d.; Monday, £29 15s. to £29 17s. 6d.; Tuesday, £30 7s. 6d. to £30 12s. 6d.; Wednesday, £30 3s. 9d. to £30 6s. 3d.

Three Months.—Thursday, £30 3s. 9d. to £30 5s.; Friday, £30 to £30 1s. 3d.; Monday, £29 12s. 6d. to £29 15s.; Tuesday, £30 2s. 6d. to £30 5s.; Wednesday, £30 to £30 1s. 3d.

Tin.—The standard market gradually drifted downward last week, owing to extended profit-taking, but recovered on Monday following the acceptance by the F.M.S. of the new cut in production—67 per cent. of capacity, to take effect from June 1. Little business has been done with consumers on either side of the Atlantic. The American tinplate mills, however, are now working to at least 50 per cent. of capacity, and are reported to be drawing heavily on their stocks of raw material. At Tuesday's meeting of the London market there was a substantial rise in prices, owing to reports that the Tin Producers' Association intended to make further drastic cuts in output. Prices rose rapidly again yesterday (Wednesday), when it became known that the proposals had been definitely agreed to by the interests concerned. The scheme aims at limiting production to 40 per cent. of capacity, the restriction to continue until the price of tin has averaged £200 per ton for a month.

Official closing prices :—

Cash.—Thursday, £113 15s. to £114; Friday, £112 5s. to £112 15s.; Monday, £114 7s. 6d. to £114 10s.; Tuesday, £120 12s. 6d. to £120 15s.; Wednesday, £126 to £126 5s.

Three Months.—Thursday, £115 17s. 6d. to £116; Friday, £114 15s. to £115; Monday, £116 10s. to £116 12s. 6d.; Tuesday, £122 15s. to £123; Wednesday, £128 5s. to £128 10s.

Spelter.—There is a steady, if limited, demand from consumers, both in this country and on the Continent. The market in America, however, remains very slow, and the East St. Louis spot quotation has fallen to 2.575 cents per lb. The projected meeting of producers has been postponed for a while, owing to the non-arrival of the Canadian delegate, but it is understood that further restriction schemes are in the air.

Daily fluctuations :—

Ordinary.—Thursday, £12 2s. 6d.; Friday, £12 1s. 3d.; Monday, £12 5s.; Tuesday, £12 15s.; Wednesday, £13.

Lead.—The United Kingdom market remains slow, owing to the poor demand for lead products, and to the fact that many consumers are already covered well ahead. Arrivals of lead in England during April were on the small side, but it is understood that there are considerable stocks in private hands. A strict control of the market is being maintained by the holders. Were this not so, the market would certainly fall, as very little interest is being shown by the consumer at the moment.

The week's prices have been :—

Soft Foreign (Prompt).—Thursday, £11 5s.; Friday, £11 5s.; Monday, £11 8s. 9d.; Tuesday, £11 15s.; Wednesday, £11 13s. 9d.

The Stanton Ironworks Company, Limited, near Nottingham, have taken over the London warehouse business in cast-iron pipes and specials of Fellowes, Williamson & Company, Limited, Seagrave Road, London. They are arranging to carry in London a large stock of cast-iron pipes and specials, available for immediate delivery. The warehouse is situated in Seagrave Road, Fulham, on the site of the Brompton and Fulham L.M.S. Railway Goods Yard, and will continue under the management of Mr. Charles Williamson.

SIEMENS' STEEL PROCESS

BOILER, SHIP and BRIDGE PLATES, etc. ANGLES and all forms of Sectional Bars. TYRES and AXLES to all requirements. CASTINGS of all kinds and of Largest Sizes. FORGINGS of every description. BILLETS, BLOOMS, RAILS.

SPECIAL STEEL FOR CONSTRUCTIVE PURPOSES.

The STEEL COMPANY OF SCOTLAND, Ltd.

Head Office: 37, RENFIELD STREET, GLASGOW:
Works: HALLSIDE, NEWTON and BLOCHAIRN, GLASGOW.

CONTRACTORS TO HOME, COLONIAL AND FOREIGN GOVERNMENTS.

Established 1872. *Telegraphic Address: "Steel, Glasgow."*

F.T.J. 5/5/32

£1,000

The 2nd International Aluminium Competition, with prizes totalling 200,000 Swiss Francs (say £1,000) opens on July 1st and closes on October 1st, 1932.

The prizes are offered for the best suggestions directed towards the development of the uses of aluminium—as, for example; in the construction of new apparatus, or in new applications of the metal or its alloys, or in improvements in working processes.

RULES ARE NOW OBTAINABLE *from the*

BUREAU INTERNATIONAL DE L'ALUMINIUM, 23, BIS RUE DE BALZAC, PARIS,

or THE BRITISH ALUMINIUM CO., LTD., ADELAIDE HOUSE, KING WILLIAM ST., LONDON E.C.4.

CAST IRON FLANGED PIPES

2 in.—12 in. & CONNECTIONS. to 24 in. dia.

WE HAVE FIFTY-TWO YEARS OF ACCUMULATED EXPERIENCE AND METAL PATTERNS.

JAMES & RONALD RITCHIE, LTD.,

Telephone: 3852 (2 Lines). **MIDDLESBROUGH.** Telegrams: "Ritchie, Middlesbrough."

Colvilles PIG IRON
BRANDS "DALZELL," "GLENGARNOCK," "CLYDE" & "MONKLAND"
HIGH GRADE HEMATITE PIG IRON
SPECIAL & ORDINARY FOUNDRY QUALITIES & FORGE
SPECIAL REFINED WITH LOW CARBON
COLVILLES LTD
GLASGOW

WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	30 3 9
Three months	30 0 0
Electrolytic	34 0 0
Tough	32 10 0
Best selected	33 0 0
Sheets	63 0 0
India	44 0 0
Wire bars	36 17 6
Do., June	36 0 0
Do., July	35 5 0
Ingot bars	36 17 6
H.C. wire rods	39 0 0
Off. av. cash, April	29 19 10½
Do., 3 mths., April	30 4 0⅜
Do., Sttlmnt., April	29 19 7½
Do., Electro, April	34 12 10⅞
Do., B.S., April	33 14 2
Do., wire bars, April	35 1 10½
Solid drawn tubes	9½d.
Brazed tubes	9½d.
Wire	6½d.

BRASS.

Solid drawn tubes	9d.
Brazed tubes	11d.
Rods, drawn	7½d.
Rods, extd. or rlld.	4½d.
Sheets to 10 w.g.	7½d.
Wire	7½d.
Rolled metal	7d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN.

	£ s. d.
Standard cash	126 0 0
Three months	128 5 0
English	127 7 6
Bars	124 0 0
Straits	124 10 0
Australian	122 2 6
Eastern	123 12 6
Banca (nom.)	132 12 6
Off. av. cash, April	109 0 10½
Do., 3 mths., April	111 3 6½
Do., Sttlmt., April	109 0 5½

SPELTER.

	£ s. d.
Ordinary	13 0 0
Remelted	11 17 6
Hard	10 17 6
Electro 99.9	15 5 0
English	13 12 6
India	12 0 0
Zinc dust	22 0 0
Zinc ashes	2 5 0
Off. aver., April	11 16 3 5/16
Aver. spot, April	11 13 4 7/8

LEAD.

	£ s. d.
Soft foreign ppt.	11 13 9
English	13 15 0
Off. average, April	11 7 3½
Average spot, April	11 4 5½

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	23 0 0
Do., V.M. ex-whf.	21 0 0
Rods	27 10 0
Boiler plates	—
Battery plates	—

ANTIMONY.

	£ s. d.
English	35 0 0 to 42 10 0
Chinese	24 5 0
Crude	16 0 0

QUICKSILVER.

	£ s. d.
Quicksilver	16 0 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	£8 5 0
45/50%	£13 0 0
75%	£17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% c. free, of Mo.	6/3 per lb.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£20 12 6
Ferro-tungsten—	
80/85%	2/- lb.
Tungsten metal powder—	
98/99%	2/3½ lb.
Ferro-chrome—	
2/4% car.	£28 17 6
4/6% car.	£25 12 6
6/8% car.	£24 0 0
8/10% car.	£23 17 6
Ferro-chrome—	
Max. 2% car.	£38 0 0
Max. 1% car.	£49 2 6
Max. 0.70% car.	£50 5 0
70% carbon-free	1/1 lb.
Nickel—80/99.5%	£225 to £230
"F" nickel shot	£217 10 0
Ferro-cobalt	8/9 lb.
Aluminium 98/99%	£95 0 0
Metallic chromium—	
96/98%	3/- lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export (nom.)	£9 0 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 5/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

South Wales—	£ s. d.	£ s. d.
Heavy steel	2 2 0	to 2 3 6
Bundled steel and shrngs.	1 17 6	to 1 18 6
Mixed iron and steel	1 17 6	to 1 19 0
Heavy cast iron	2 5 0	
Good machinery for foundries	2 7 6	
Cleveland—		
Heavy steel	1 15 0	
Steel turnings	1 12 6	
Cast-iron borings	1 6 0	
Heavy forge	2 15 0	
W.I. piling scrap	2 7 6	
Cast-iron scrap	1 18 0	to 2 0 0
Midlands—		
Light cast-iron scrap	1 17 6	
Heavy wrought iron	2 12 6	
Steel turnings, f.o.r.	1 1 6	
Scotland—		
Heavy steel	1 17 6	
Ordinary cast iron	2 3 6	
Engineers' turnings	1 10 0	
Cast-iron borings	1 11 6	
Wrought-iron piling	2 2 6	
Heavy machinery	2 7 6	

London—Merchants' buying prices delivered yard.

	£ s. d.
Copper (clean)	25 0 0
Brass	18 0 0
Lead (less usual draft)	10 0 0
Tea lead	8 0 0
Zinc	6 10 0
New aluminium cuttings	72 0 0
Brassiery copper	22 0 0
Gunmetal	21 0 0
Hollow pewter	70 0 0
Shaped black pewter	50 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	61/-
Foundry No. 3	58/6
Foundry No. 4	57/6
Forge No. 4	57/-
Hematite No. 1	64/-
Hematite M/Nos.	63/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	72/-
d/d Birm.	84/6
Malleable iron d/d Birm.	117/6
Midlands—	
Staffs common*	—
No. 4 forge*	61/-
No. 3 fdry.*	66/-
Shrops basic	—
Cold blast, ord.	—
roll iron	—
Northants forge*	57/6
fdry. No. 3*	62/6
fdry. No. 1*	65/6
Derbyshire forge*	61/-
fdry. No. 3*	66/-
fdry. No. 1*	69/-
basic*	—

*d/d Black Country dist.

Scotland—	
Foundry No. 1	72/-
No. 3	69/6
Hem. M/Nos. d/d	68/6
Sheffield (d/d district)—	
Derby forge	58/6
fdry. No. 3	63/6
Lincs forge	—
fdry. No. 3	63/6
E.C. hematite	75/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby forge	62/-
fdry. No. 3	67/-
Staffs fdry. No. 3	67/-
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	86/6 to 87/-
Clyde, No. 3	86/6 to 87/-
Monkland, No. 3	86/6 to 87/-
Summerlee, No. 3	86/6 to 87/-
Eglinton, No. 3	86/6 to 87/-
Gartsherrie, No. 3	86/6 to 87/-
Shotts, No. 3	86/6 to 87/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)	9 15 0	
Nut and bolt iron	8 5 0	to 8 7 6
Hoops	10 10 0	to 12 0 0
Marked bars (Staffs) f.o.t.	12 0 0	
Gas strip	10 10 0	to 12 0 0
Bolts and nuts, ¾ in. × 4 in.	12 0 0	
Steel—		
Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.	8 10 0	to 9 5 0
Chequer plts.	10 7 6	
Angles	8 7 6	
Tees	9 7 6	
Joists	8 15 0	
Rounds and squares, 3 in. to 5½ in.	9 7 6	
Rounds under 3 in. to ¾ in. (Untested)	8 12 6	& up.
Flats—8 in. wide and over	8 12 6	
under 8 in. and over 5 in.	8 17 6	
Rails, heavy	8 5 0	to 8 10 0
Fishplates	12 0 0	
Hoops (Staffs)	9 10 0	
Black sheets, 24g.	8 0 0	to 8 10 0
Galv. cor. shts.	9 5 0	to 10 0 0
Galv. flat shts.	9 15 0	to 11 0 0
Galv. fencing wire, 8g. plain	12 7 6	
Billets, soft	5 7 6	to 5 12 6
Billets, hard	6 12 6	
Sheet bars	4 15 0	to 5 7 6
Tin bars	4 15 0	

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	11½d.
Rods	11 d.
Tubes	16½d.
Castings	12½d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	15.59
No. 2 foundry, Valley	15.60
No. 2 foundry, Birm.	11.00
Basic	16.39
Bessemer	17.39
Malleable	17.39
Grey forge	16.89
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	43.00
Billets	27.00
Sheet bars	26.00
Wire rods	37.00
	Cents.
Iron bars, Phila.	2.11
Steel bars	1.60
Tank plates	1.60
Beams, etc.	1.60
Skelp, grooved steel	1.50
Skelp, sheared steel	1.50
Steel hoops	1.65
Sheets, black, No. 24	2.20
Sheets, galv., No. 24	2.85
Wire nails	1.95
Plain wire	2.20
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$4.75

COKE (at ovens).

Welsh foundry	22/6 to 27/6
furnace	16/6 to 17/6
Durham and Northumberland—	
foundry	14/6 to 15/-
furnace	13/- to 13/6
Midlands, foundry	—
furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	14/6 to 15/-
	28×20 "	29/- to 30/-
	20×10 "	—
	18⅞×14 "	—
C.W.	20×14 "	13/6
	28×20 "	—
	20×10 "	—
	18⅞×14 "	—

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6 0 0 to £7 0 0
Bars, hammered, basis	£16 10 0 to £17 0 0
Bars and nail-rods, rolled, basis	£15 17 6 to £16 5 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£32 0 0 to £33 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
Apr.	28 ..	30	1	3	dec.	3/9
,,	29 ..	30	1	3	No change	
May	2 ..	29	15	0	dec.	6/3
,,	3 ..	30	7	6	inc.	12/6
,,	4 ..	30	3	9	dec.	3/9

Electrolytic Copper.

		£	s.	d.		
Apr.	28 ..	34	10	0	No change	
,,	29 ..	34	10	0	,,	,,
May	2 ..	34	5	0	dec.	5/-
,,	3 ..	34	5	0	No change	
,,	4 ..	34	0	0	dec.	5/-

Standard Tin (cash).

		£	s.	d.		
Apr.	28 ..	113	15	0	dec.	15/-
,,	29 ..	112	5	0	,,	30/-
May	2 ..	114	7	6	inc.	42/6
,,	3 ..	120	12	6	,,	125/-
,,	4 ..	126	0	0	,,	107/6

Tin (English ingots).

		£	s.	d.		
Apr.	28 ..	115	0	0	dec.	15/-
,,	29 ..	113	15	0	,,	25/-
May	2 ..	115	15	0	inc.	40/-
,,	3 ..	122	0	0	,,	125/-
,,	4 ..	127	7	6	,,	107/6

Spelter (ordinary).

		£	s.	d.		
Apr.	28 ..	12	2	6	dec.	7/6
,,	29 ..	12	1	3	,,	1/3
May	2 ..	12	5	0	inc.	3/9
,,	3 ..	12	15	0	,,	10/-
,,	4 ..	13	0	0	,,	5/-

Spelter (Electro, 99.9 per cent.).

		£	s.	d.		
Apr.	28 ..	14	7	6	dec.	12/6
,,	29 ..	14	7	6	No change	
May	2 ..	14	10	0	inc.	2/6
,,	3 ..	15	0	0	,,	10/-
,,	4 ..	15	5	0	,,	5/-

Zinc Sheets (English).

		£	s.	d.		
Apr.	28 ..	23	0	0	No change	
,,	29 ..	23	0	0	,,	,,
May	2 ..	23	0	0	,,	,,
,,	3 ..	23	0	0	,,	,,
,,	4 ..	23	0	0	,,	,,

Lead (English).

		£	s.	d.		
Apr.	28 ..	13	5	0	dec.	5/-
,,	29 ..	13	5	0	No change	
May	2 ..	13	5	0	,,	,,
,,	3 ..	13	15	0	inc.	10/-
,,	4 ..	13	15	0	No change	

AVERAGE MONTHLY PRICES OF STEEL RAILS.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1917	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6
1918	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6
1919	10 17 6	13 7 6	13 7 6	13 7 6	15 0 0	15 10 0	16 0 0	16 10 0	16 10 0	16 10 0	16 10 0	17 5 0	14 12 11
1920	18 15 0	19 5 0	20 7 6	22 0 0	23 0 0	23 0 0	24 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	22 18 11½
1921	22 5 0	20 4 0	18 0 0	17 0 0	15 0 0	15 0 0	14 0 0	14 0 0	14 0 0	11 12 6	10 10 0	10 0 0	15 4 3
1922	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 0 0	8 15 0	8 15 0	8 15 0	8 15 0	9 4 2
1923	8 17 6	9 2 0	10 5 0	10 10 0	10 10 0	10 10 0	9 15 0	9 0 0	8 15 0	8 15 0	8 19 0	9 5 0	9 9 10
1924	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 2 6	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 2 3½
1925	9 0 0	9 0 0	9 0 0	9 0 0	8 15 0	8 10 7½	8 10 0	8 10 0	8 10 0	8 4 0	8 0 0	8 0 0	8 11 7½
1926	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 7 6	8 10 0	8 10 0	8 10 0	8 10 0	8 3 11½
1927	8 10 0	8 10 0	8 10 0	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 3 0	8 5 0	8 5 0	8 4 10
1928	8 5 0	8 5 0	8 5 0	8 5 9	8 6 3	8 6 3	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 7 9½
1929	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0
1930	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0
1931	8 9 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 8
1932	8 7 6	8 7 6	8 7 6	8 7 6	—	—	—	—	—	—	—	—	—

AVERAGE MONTHLY PRICES OF EAST COAST HEMATITE AT MIDDLESBROUGH.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1916	133 9	140 0	136 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	128 1½
1917	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6
1918	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6
1919	122 6	122 6	122 6	122 6	179 2	190 0	197 6	200 0	200 0	200 0	200 0	200 0	171 4
1920	220 0	220 0	240 0	260 0	260 0	260 0	260 0	260 0	260 0	260 0	260 0	260 0	251 8
1921	240 0	220 0	180 0	180 0	180 0	160 0	160 0	160 0	137 0	127 6	117 6	104 6	162 2
1922	97 6	91 7½	100 0	98 6	97 1½	94 7	93 6	90 9	89 7	91 10½	93 0	93 2	94 5½
1923	94 6	104 9	122 0	126 10½	122 0	115 3	107 0	98 8½	98 10½	99 1½	100 6½	102 3	107 10½
1924	102 4½	101 3	99 7½	99 0	98 9½	97 4½	95 3½	93 1½	90 7½	88 0	88 4½	88 6	95 2½
1925	87 5	85 9	84 7½	82 6	80 10½	79 3	77 1½	75 7½	75 0	74 3½	74 9	76 0	79 5½
1926	77 3	77 9	77 3½	76 3	77 4½	78 0	79 8½	81 9	83 4½	87 7½	92 6	90 5½	81 7½
1927	90 0	90 0	86 3½	83 1½	80 6	78 0	76 6	75 4½	75 0	72 9	71 9	71 1½	79 2½
1928	69 7½	69 7½	69 9	70 0	70 0	69 3	68 7½	69 2	70 0	70 0	70 3	71 0	69 9½
1929	71 6	72 0	73 6	74 0	74 0	74 1½	74 9	75 6	76 1½	76 8½	78 1½	79 0	74 11½
1930	78 2½	78 0	76 9	75 0	74 0	72 7½	71 0	71 0	71 0	71 0	70 10½	70 4½	73 3½
1931	70 0	69 0	68 0	66 8½	65 1½	63 4½	62 9	61 1½	65 0	65 0	65 0	65 0	65 6
1932	64 10	64 3	63 6	63 6	—	—	—	—	—	—	—	—	—

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EMPLOYMENT REGISTER.

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Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

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THE Metropolitan Water Board invite Tenders for the supply of the undermentioned STORES and SERVICES, etc., for periods of 6 and 12 months commencing June 1, 1932 :—

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22	Timber.
23	Maintenance of Weighing Machines.

Tenders must be submitted on the official forms, which may be obtained on and after Friday, April 29, 1932, from the Chief Engineer, by personal application at the offices of the Board (Room 155) or upon forwarding a stamped addressed sack envelope.

Applicants should refer to the number of the Tender for which forms are required.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board," and endorsed in the manner indicated in the Form of Tender, must be delivered at the Offices of the Board (Room 122) not later than 11 a.m. on Wednesday, May 18, 1932.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
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April 23, 1932.

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